July 1977
Volume 21
Number 4

Mariners Weather Log

National Oceanic and Atmospheric Administration • Environmental Data Service

U.S. DEPARTMENT OF COMMERCE
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Mariners Weather Log

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July 1977
Volume 21 Number 4
Washington, D.C.

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Cover: Illegal parking was the result of supertyphoon Pamela's estimated 145-kn gusts on Guam. For details, see article "Western North Pacific Typhoons, 1976" on page 224. Courtesy Air Weather Service Observer.

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The Secretary of Commerce has determined that the publication of this periodical is necessary in the transaction of the public business required by law of this Department. Use of funds for printing this periodical approved by the Director of the Office of Management and Budget through June 30, 1980.

Copies are available to persons or agencies with a marine interest from the Environmental Data Service, D762, Page Building 1, Room 400, Washington, D.C. 20235. Telephone 202-634-7395. Telephone 202-634-7394.

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Mariners Weather Log

SAND WAVES

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The modern supertanker is required to sail through many areas with a clearance of only 2 to 3 ft. Many cannot enter the Baltic Sea at all and must use extreme caution in the North Sea, the Straits of Malacca, and the Dover Straits. Charts must be accurate. Wrecks and submarine cables must be charted. Perhaps the most dangerous hazards in many areas are sand waves because they can shift. These mobile undersea dunes are fast becoming a concern to the mariner and the marine engineer.

Migrating sand waves can cause changes in charted water depths. They can bury wellheads or expose pipelines. They can free or shift anchors of sea-bottom mines. They can cover or uncover wrecks or other navigational hazards.

Sand waves were discovered when early acoustic depth sounding devices showed some large, unanticipated triangular-shaped humps that looked like the edge of a saw. The early profiles were obtained in the southern part of the North Sea. Since then, sand waves of various sizes and shapes have been found wherever there are strong currents and an abundant supply of unconsolidated sand on the sea floor.

Excluding occurrences in rivers, at least 40 areas have been found in which sand waves occur. Most of these localities are in estuaries or tidal entrances including an area inside the Golden Gate, in the entrances to the Delaware and Chesapeake Bays, the Bay of Fundy, Persian Gulf, English Channel, Irish Sea, and the Thames and Elbe Rivers.

Sand waves look like a mammoth version of the sediment ripples seen in shallow pools on sandy beaches. They commonly measure 15 to 25 ft in height. However, at the entrance to Sofala Bay, Mozambique, sand waves 85 ft high have been reported. Wavelengths (crest-to-crest measurement) fall in the 100- to 1,000-ft range although they have been observed up to 2,500 ft. Slopes range from less than 2 to more than 30 degrees.

In an ideal plan view, a field of sand waves consists of long, straight parallel ridges of sediment separated by intervening troughs. In reality, sand waves usually display sinuous or branching crest patterns with relatively poor crest continuity. There is considerable variation in height along a single crest, with a maximum often occurring where sand waves join together or intersect.

In a profile view, sand waves can be classified in three categories: symmetrical, asymmetrical, or partially symmetrical. Some profiles are called "cat backs" and consist of broad, gently rounded humps on one side, a sharply pointed "ear" or crest at the top, and a steep slope on the remaining side. Owing to the vertical exaggeration of scales on echo-sounder records, slopes are deceptive. Slopes on large marine waves are often less than 2 degrees.

Early scientific observations of sand waves consisted of peering through shallow water, examining those exposed on banks at low tide, and measuring successive bed changes relative to staked grids. Wavelengths of small sand waves were determined in greater water depths from the pattern of sand grains adhering to a tallow-coated sounding lead lowered in a horizontal attitude. Surveying of sand waves by wireline sounding was followed by echo-sounding, side-looking sonar, diving, continuous seismic reflection profiling, and underwater television. A few areas have been studied by comparison of successive charts.

Sand waves are nearly always associated with tidal currents and a flow constriction of some kind, either horizontal or vertical, that results in increased current velocity. They often occur in channels or atop banks. Tidal channels are a likely place.

Tidal channels are formed by the deposition of sediment on the bottom of a shallow water body subject to tides. This action ultimately produces a pattern of shoals and intervening tidal channels. An example of this pattern is shown in the bottom-flow pattern at the

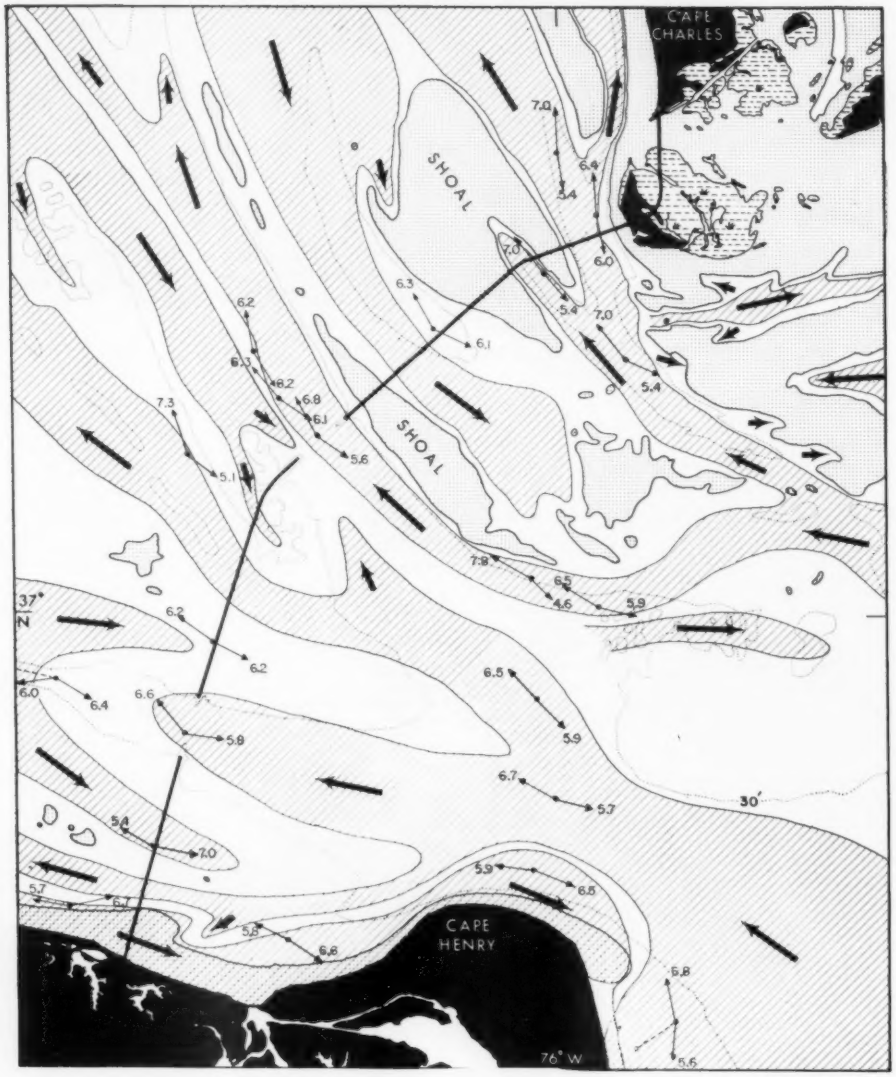

Figure 1.--An hydraulic and geomorphic interpretation of the net nontidal (residual) flow pattern at the bottom in the entrance to Chesapeake Bay. Numbers are measured flood and ebb flow durations at the bottom in hours; small arrows show measured direction of near-bottom currents. Stippled areas are shoaler than 18 ft. Ruled areas show where there is an ebb or a flood flow predominance. Large arrows indicate which is predominant. Nonpatterned areas are neutral.

entrance to the Chesapeake Bay in figure 1. Studies of the tidal lagoons of Holland compare these channel configurations to the branching pattern of trees. For example, there is a dendritic, apple tree design and a linear, slender poplar pattern. In English estuaries it was noted that the tidal flood took a direct shortcut path toward the head of the estuary moving up and over shoals and shallow flats. Ebb flow on the other hand tended to be somewhat more confined to the deeper, main meandering channels. Maximum flood and ebb flows even within the same channel tended to follow mutually evasive paths.

This mutual evasion results in several distinct arrangements of ebb and flood channels with associated shoals. Figure 2 shows the more common arrangements. These can also be recognized in figure 1. A flood channel is one which is open to currents which are strongest during flood flow, while an ebb channel is open to currents that attain a maximum velocity during ebb flow. Water in the channels and over the shoals experiences tidal reversal at all depths.

Sand-wave bedforms develop on the bottom of many

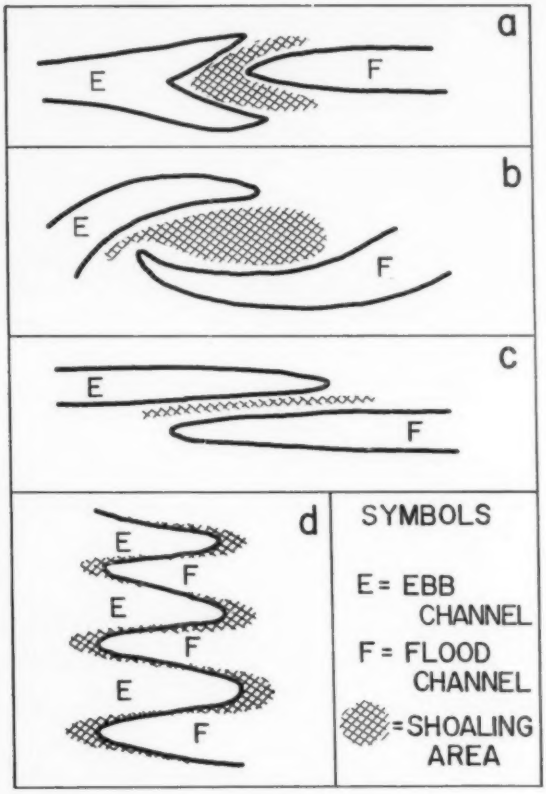

Figure 2.--Four idealized arrangements of interdigitating ebb and flood tidal channels as seen in map view. Mutual evasion of ebb and flood channels is the underlying motif. A, forked channel with parabolic shoal; B, flanking channels with airfoil-shaped shoal; C, parallel channels with linear shoal; D, wide estuary pattern with zigzag shoals.

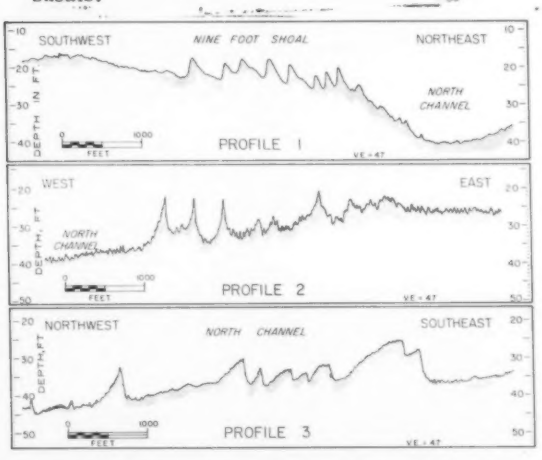

Figure 3.--Echo sounding profiles of the bottom showing sand waves on three profiles. Locations of the profiles are shown in figure 4.

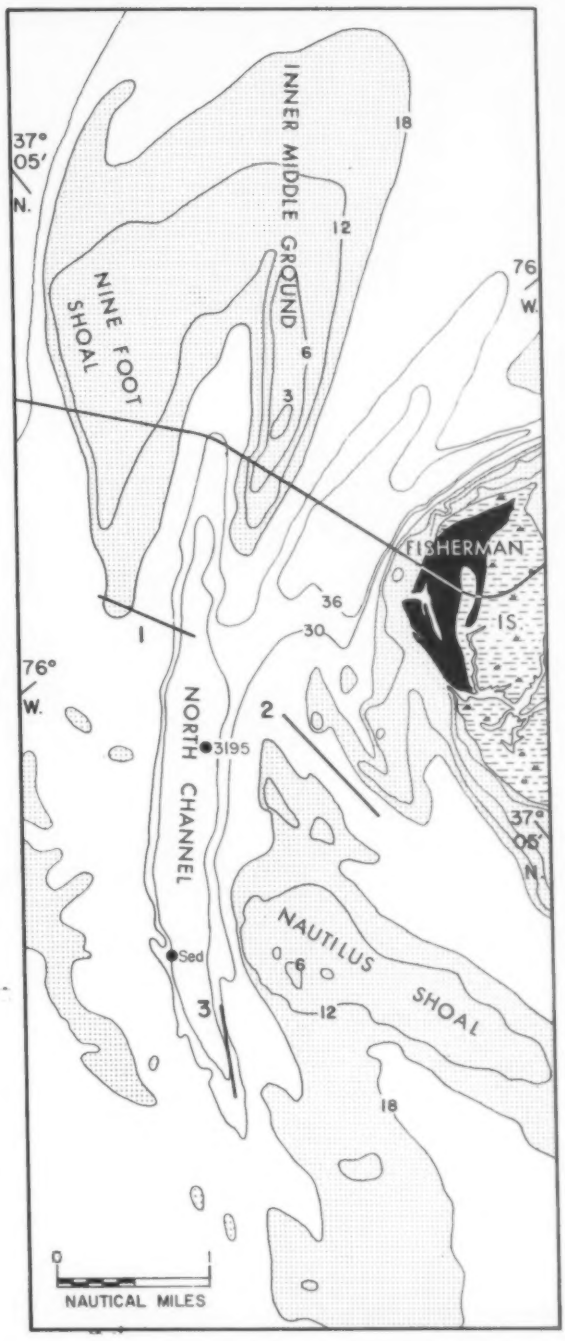

Figure 4.--Shoal and tidal channel bathymetry in the northern part of the entrance to Chesapeake Bay. Numbered profiles are shown in figure 3. Current measurement and bottom sampling sites are shown.

tidal channels. Their shape and migration depend on the flood and ebb tides. If the reversing currents are of equal strength and duration, a symmetrical or trochoidal profile results. If ebb and flood currents are unequal in strength or duration, then a profile of intermediate symmetry, aptly named an asymmetrical-trochoidal profile, is formed. Asymmetrical profiles are the result of a dominant ebb or flood current or a unidirectional flow, such as in a river. Examples of asymmetrical-trochoidal and the asymmetrical profiles can be seen in figure 3, which contains echo soundings taken from the entrance to the Chesapeake Bay (fig. 4). Profile 1 shows asymmetrical sand waves facing west-southwestward in the general direction of the tidal current. They average 5 ft in height, and wavelengths average 250 ft. In profile 2, asymmetrical-trochoidal sand waves are up to 12 ft high with 300-ft wavelengths. The features in profile 3 range in wavelength from 200 to 1,200 ft and in height from 2 to 12 ft. All of these forms are asymmetrical in profile and face seaward with the ebb tidal current.

The undulating or waviform appearance of sand-wave beds is caused by the currents in the overlying water. These currents may result from any combination of density distribution, wind and wave, and tide action. If these bottom current vectors are sufficient in magnitude to entrain and move the sediment present, then the resultant vector, over a suitable period, is an important predictor of sand wave form and migration direction. A zero resultant vector is an indication that the profile of any transverse sand waves should be symmetric, while a nonzero vector should result in a nonsymmetrical shape.

Early studies related the movement of sand waves to fluid flow velocity. While this does have a large effect on migration rate, other factors are of considerable importance. Sand-wave migration is more probably associated with the movement of bed sediment than with fluid flow velocity. Unfortunately, at the present time there are many unsolved problems of initiation of sediment motion, turbulent transport, and non-Newtonian behavior of sediment-ladened suspensions. These present serious obstacles to a full physical understanding of the travel rate of sand waves. Among the relevant factors are: particle properties, including density, size, shape, and cohesion; fluid properties, including density, viscosity, and, therefore, temperature; boundary properties, including roughness, sand-wave height, wavelength, and bed slope; and, finally, water depth or depth below an internal fluid flow boundary. The shear stress exerted by the moving fluid on the bed is the key factor in sediment transport and sand-wave migration.

Migration of strongly asymmetrical forms occurs by bed erosion on the upstream slope of the wave and by deposition on the downstream face which builds forward by intermittent or continuous avalanching of sediment. These asymmetrical sand waves are formed by a strong, unidirectional flow, such as in a river, and often exhibit steep downstream faces with a sediment slope of 15 to 30 degrees on the facing side. Asymmetrical types migrate with speeds that range from a fraction of a yd per mo, as for example at the mouth of the Loire estuary (France), to 2,100 ft per day as in the Brahmaputra River at Aricha, East Pakistan. Certain fields of large asymmetrical sand waves in the North Sea off the Netherlands did not undergo migration within detectable limits of 200 ft over a 2-1/2 yr survey period. However, this may be an indication only of a very slow rate of migration.

Trochoidal or symmetric forms migrate very slowly, if at all. Small symmetric forms on a level bottom may oscillate under reversing flow, but do not undergo detectable net translation. Wave beds that are asymmetric-trochoidal migrate slowly in the direction of the net or residual current and are steeper downstream.

Dominant tidal currents and facing directions are strongly correlated. This enables the mapping of probable regional sand distribution pathways from the facing direction of sand waves. Although small sediment ripples may be reversed in their facing direction by each ebb and flood, the large sand waves with a wavelength of 20 ft or more apparently maintain their facing directions. In places where there is a closed end to a channel, sand waves face this end in conformance with the predominant tidal current.

Sand-wave migration rates also vary seasonally in some estuaries and tidal rivers. In the Loire River, Ballade (1953) found that during the season of low runoff, sand waves at Ile de Bois, 20 mi from the mouth of the River, experienced only back and forth excursions of 10 to 25 ft, and only the tops of the bed features were affected. During the season of high runoff, the ebb current was aided, sand-wave asymmetry developed, and the entire train migrated downstream at a rate of 7.8 ft per day under peak discharge.

Sand waves of large amplitude advance more slowly than small sand waves of identical profile form, if the bed sediment transport rate per unit width of channel is the same for both features. Large sand waves have a large sediment storage volume and thus require more sediment to move a unit distance. A consequence of the rapid movement of small bedforms is that they overtake larger features in the same wave train, merge with them, increase the size of the larger forms, and increase the incidence of long wavelengths by decreasing the incidence of short wavelengths. If this is true, then sand-wave height should increase with distance in the direction of migration. It is a corollary of this theory that larger sand waves are older waves. In sand-wave trains, it has been observed that the height of successive waves on some sand banks increases the facing direction of the waves up to the place where the train terminates at a steeply sloping bank edge or "cliff."

In shipping lanes in the southern part of the North Sea, particularly where a bathymetric channel or deep area ends and a shallow divide must be crossed to enter another bathymetric channel, the tops of sand waves on the bottom can constitute a hazard to hull bottoms of deep-draft vessels. In such areas, frequent mapping of the bottom may become necessary for navigational safety. There is a need for up-to-date bathymetric data on charts in these and other similar areas.

Sand waves have attracted great attention for engineers and scientists over a period of many years. The origin and dynamics of these features, however, are still not well understood. Echo sounding paper records of large, unusual, or shallow sand waves are an important source of information. The author would welcome receiving any records of this kind for future study.

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Mariners Weather Log

WESTERN NORTH PACIFIC TYPHOONS, 1976

Extracted from Annual Typhoon Report, 1976, U.S. Fleet Weather Central, Joint Typhoon Warning Center, Guam, Mariana Islands.

In 1976 the number of tropical cyclones remained below the long-term average. There were 25 tropical cyclones of which 14 attained typhoon intensity, including 4 supertyphoons (table 1). March was the only month without a tropical cyclone, while February, March, November, and December were without a typhoon (tables 2 and 3).

The storm season had an early debut with typhoon Kathy forming in January. The near equatorial trough was firmly established by April and maintained itself throughout most of the remainder of the year. An exception was late September and most of October, when the westerly flow along the Equator gave way to easterly trades.

There were 53 days of multiple-storm situations. As early as May, simultaneous storms were generated when Olga and Pamela tracked across the western Pacific causing extensive damage to the Philippines and Guam. June through September saw six additional two-storm situations and one three-storm situation. Although the season started quickly, the latter part of the season tapered off earlier than normal. For 36 days in September and October, normally a very active period, no warnings were issued. Not since 1958, when 30 days passed without a depression, has such a lull in activity occurred during this time of the year.

Most of the damage during 1976 was associated with three of the four supertyphoons. Damage estimates to public and private property for Pamela and Fran combined exceeded $1 billion. Fran also left 133 persons dead in Japan. While Pamela was responsible for 10 deaths on Truk, the supertyphoon miraculously caused only 1 fatality as it passed over Guam. Therese sank 12 ships and left 1,300 homeless from the heavy rains in southern Japan. During May, Olga caused enhanced monsoonal rains over the Philippines which led to over 200 deaths and left thousands homeless. In addition, typhoon Billie generated great waves, resulting in the drowning of 41 fishermen and swimmers as the storm passed through the Ryukyu Islands. Billie was subsequently responsible for four deaths in Taipei and caused millions of dollars of damage to facilities during passage over northern Taiwan. Although Marie caused no known fatalities, she caused millions of dollars damage to crops and structures in the Palau Islands. In September, Iris sank a Panamanian freighter and killed four persons as she tracked slowly across the South China Sea.

The cyclone tracks shown in figures 5 to 9 are based on poststorm analysis. Dates include the period from when the storm was first detected until it dissipated or became extratropical. The maximum winds are overwater estimates of sustained windspeeds for a 1-min averaging period.

Individual typhoons are described in the following narratives. Times are GMT. Tropical storm sum-

Table 1.--Western North Pacific tropical cyclones, 1976

Name	Intensity	Period of Warning	Maximum surface wind (kn)	Minimum observed sea level pressure(mb)
Kathy	TY	Jan. 28-Feb. 2	80	969
Lorna	TS	Feb. 27-March 1	35	---
Marie	TY	April 3-14	115	929
Nancy	TS	April 25-May 2	55	984
Olga	TY	May 12-27	100	934
Pamela	STY	May 14-27	130	921
Ruby	TY	June 23-July 4	120	934
Sally	TY	June 24-July 3	115	923
Therese	STY	July 11-20	135	903
Violet	TS	July 21-25	55	---
Wilda	TS	July 22-24	45	992
Anita	TY	July 23-25	65	979
Billie	TY	August 3-10	125	914
Clara	TS	August 5-7	40	---
Dot	TS	August 18-23	50	989
Ellen	TS	August 20-24	45	993
Fran	STY	September 3-13	130	913
Georgia	TS	September 9-15	40	992
Hope	TY	September 14-17	70	981
Iris	TY	September 14-21	75	967
Joan	TY	September 19-24	70	---
Kate	HR	(Central North Pacific hurricane)		
Louise	STY	Oct. 30-Nov. 7	140	895
Marge	TS	November 6-11	60	977
Nora	TS	December 3-8	45	992
Opal	TS	December 9-10	35	996

TY - typhoon; TS - tropical storm; STY - supertyphoon; HR - hurricane;

Table 2.--Frequency of tropical storms and typhoons by month and year

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Average (1945-58)	0.4	0.1	0.4	0.5	0.8	1.3	3.0	3.9	4.1	3.3	2.7	1.1	22.0
1959	0	1	1	1	0	0	3	6	6	4	2	2	26
1960	0	0	0	1	1	3	3	10	3	4	1	1	27
1961	1	1	1	1	3	2	5	4	6	5	1	1	31
1962	0	1	0	1	2	0	6	7	3	5	3	2	30
1963	0	0	0	1	1	3	4	3	5	3	0	3	25
1964	0	0	0	0	2	2	7	9	7	6	6	1	40
1965	2	2	1	1	2	3	5	6	7	2	2	1	34
1966	0	0	0	1	2	1	5	8	7	3	2	1	30
1967	1	0	2	1	1	1	6	8	7	4	3	1	35
1968	0	0	0	1	1	3	3	8	3	6	4	0	27
1969	1	0	1	1	0	0	3	4	3	3	2	1	19
1970	0	1	0	0	0	2	2	6	4	5	4	0	24
1971	1	0	1	3	4	2	8	4	6	4	2	0	35
1972	1	0	0	0	1	3	6	5	4	5	2	3	30
1973	0	0	0	0	0	0	7	5	2	4	3	0	21
1974	1	0	1	1	1	4	4	5	5	4	4	2	32
1975	1	0	0	0	0	0	2	4	5	5	3	0	20
1976	1	1	0	2	2	2	5	3	5	1	1	2	25
Average (1959-76)	0.6	0.4	0.4	0.9	1.3	1.6	4.7	5.8	4.9	4.2	2.5	1.2	28.4

Table 3.--Frequency of typhoons by month and year

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Average (1945-58)	0.4	0.1	0.3	0.4	0.7	1.1	2.6	2.9	3.2	2.4	2.0	0.9	16.3
1959	0	0	0	1	0	0	1	5	3	3	2	1	20
1960	0	0	0	1	0	2	2	8	0	4	1	1	19
1961	0	0	1	0	2	1	3	3	3	3	1	1	20
1962	0	0	0	1	2	0	5	7	2	4	3	0	24
1963	0	0	0	1	1	2	3	3	3	4	0	2	19
1964	0	0	0	0	2	2	6	3	5	3	4	1	26
1965	1	0	0	1	2	2	4	3	5	2	1	0	21
1966	0	0	0	1	2	1	3	6	4	2	0	1	20
1967	0	0	1	1	0	1	3	4	4	3	3	0	20
1968	0	0	0	1	1	1	1	4	3	5	4	0	20
1969	1	0	0	1	0	0	2	3	2	3	1	0	13
1970	0	1	0	0	0	1	0	1	2	3	1	0	12
1971	0	0	0	3	1	2	6	3	3	3	1	0	24
1972	1	0	0	0	1	1	4	4	3	1	2	2	22
1973	0	0	0	0	0	0	4	2	2	4	0	0	12
1974	0	0	0	0	1	2	1	2	3	1	2	0	13
1975	1	0	0	0	0	0	1	3	3	3	2	0	14
1976	1	0	0	1	2	2	3	0	4	1	0	0	14
Average (1959-76)	0.3	0.1	0.1	0.7	0.9	1.1	2.9	3.7	3.3	3.2	1.6	0.5	18.7

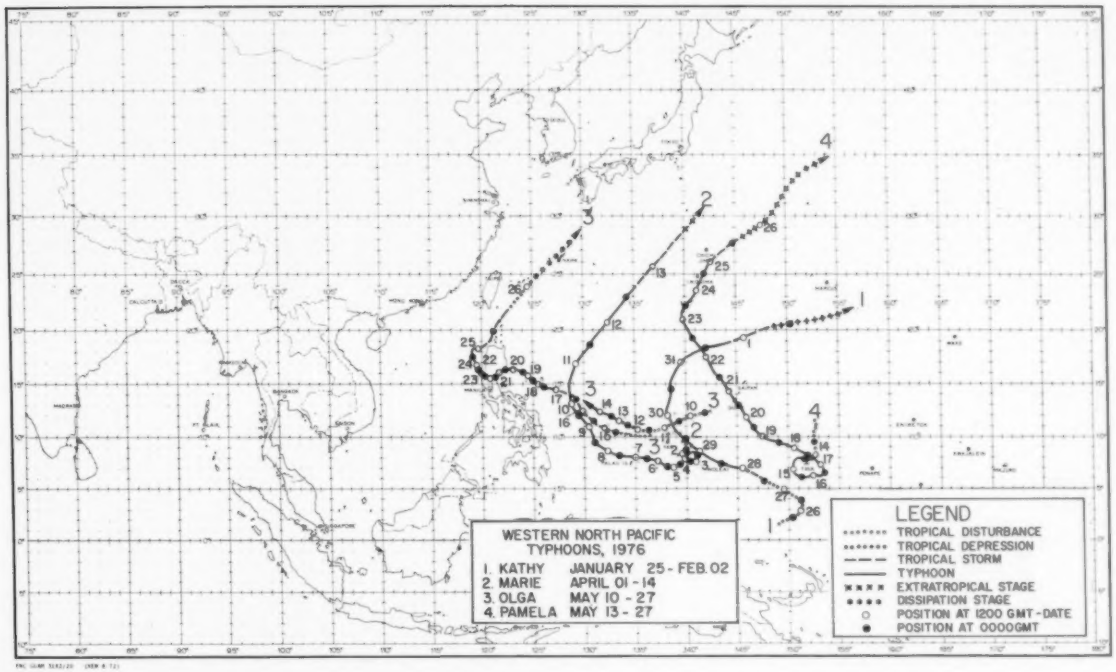


Figure 5.--Tracks of western North Pacific typhoons, January - May 1976.

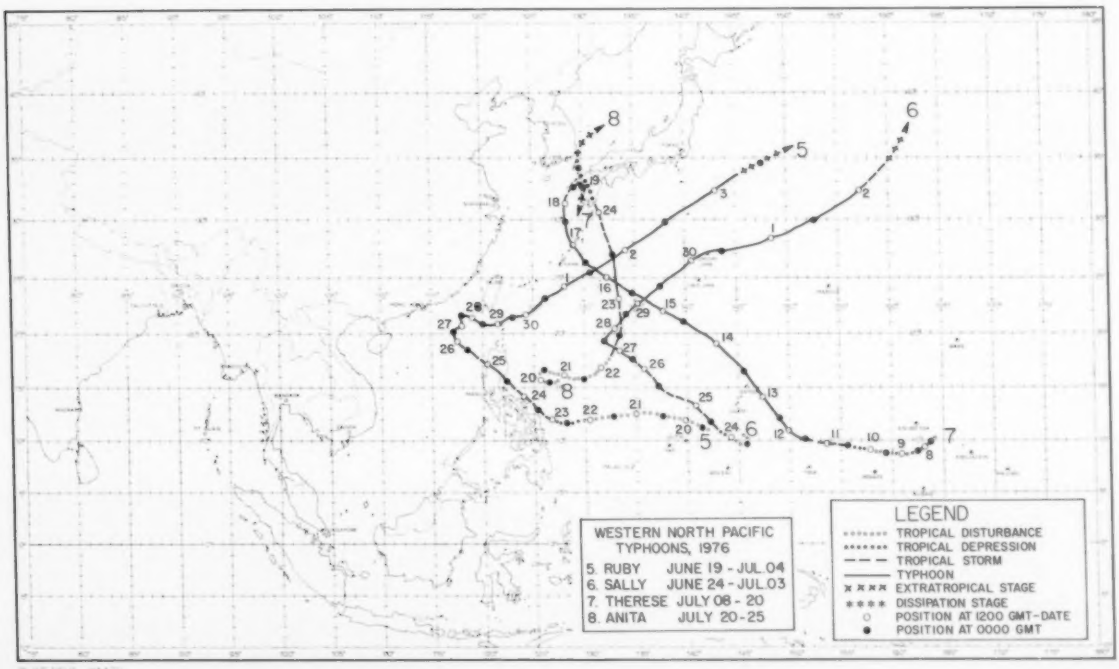


Figure 6.--Tracks of western North Pacific typhoons, June - July 25, 1976.

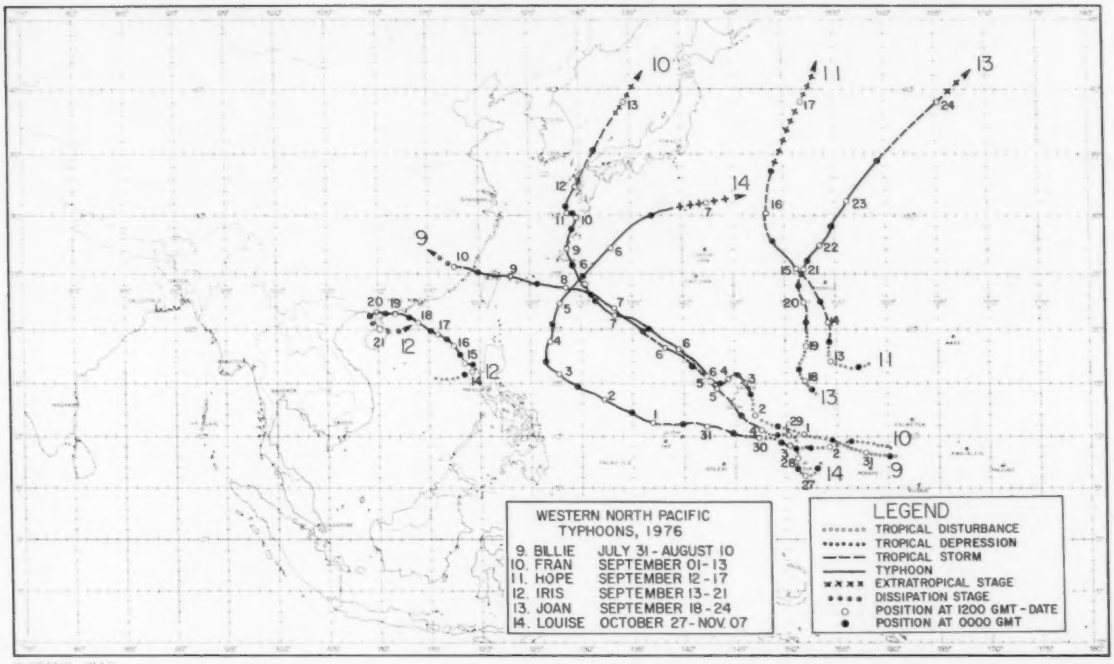


Figure 7.--Tracks of western North Pacific typhoons, July 31 - November 1976.

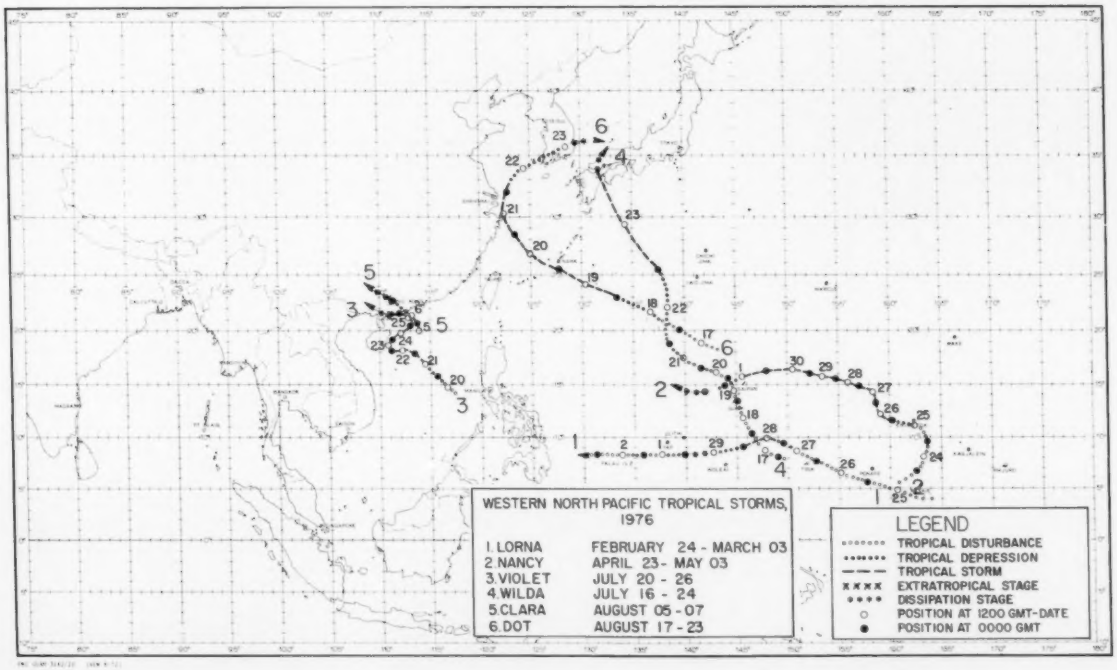


Figure 8.--Tracks of western North Pacific tropical storms, January - August 23, 1976.

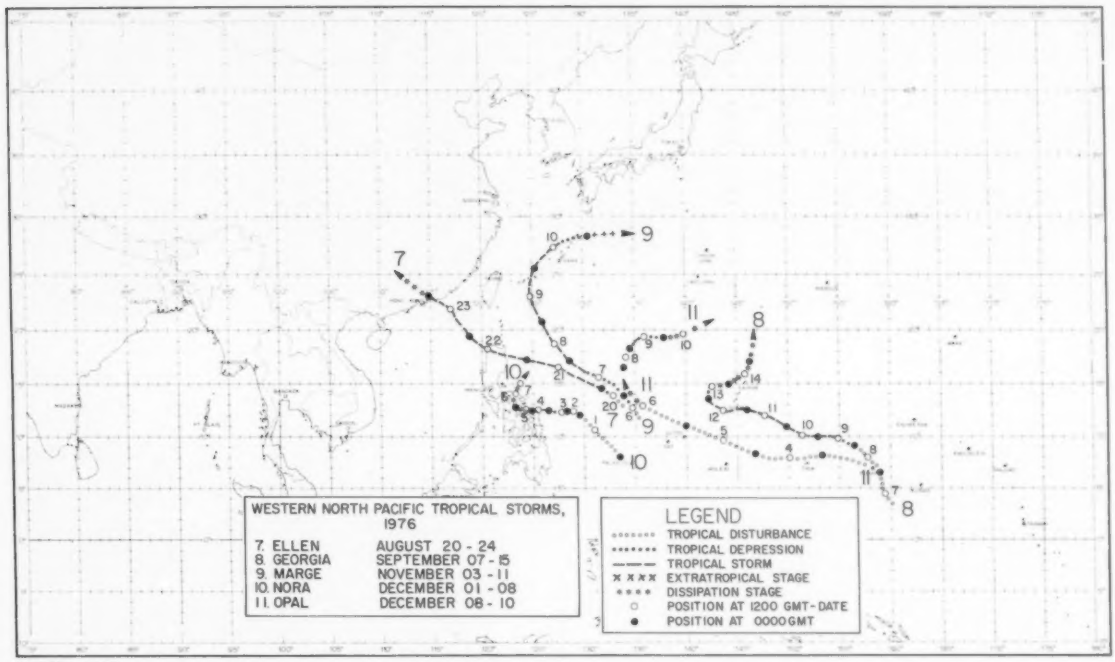

WESTERN NORTH PACIFIC TROPICAL STORMS, 1976
7. ELLEN AUGUST 20 - 24
8. GEORGIA SEPTEMBER 07 - 15
9. MARGE NOVEMBER 03 - 11
10. NORA DECEMBER 01 - 08
11. OPAL DECEMBER 08 - 10
LEGEND
TROPICAL DISTURBANCE
TROPICAL DEPRESSION
TROPICAL STORM
EXTRATROPICAL STAGE
DISSIPATION STAGE
POSITION AT 1200 GMT - DATE
POSITION AT 0000 GMT

Figure 9.--Tracks of western North Pacific tropical storms, August 20 - December 1976.

maries can be found in the "Smooth Log" in the appropriate issue of Mariners Weather Log.

KATHY

The first typhoon of the 1976 season, a January storm, was initially detected by ship reports on the morning of the 25th as a cyclonic circulation unusually close to the Equator. During the next 3 days the disturbance intensified as it moved northeastward and then northwestward. On the morning of the 29th, reconnaissance aircraft indicated the circulation was nearly at tropical storm intensity. During the next 48 hr, tropical storm Kathy moved northwestward at 12 to 13 kn.

Late on the 30th, a deep midlatitude trough moved eastward into the Philippine Sea, weakening the midtropospheric subtropical ridge, and in response Kathy intensified to a typhoon and moved northward slowing to 10 kn. By that evening, the typhoon was drifting northward through the weakness in the ridge and still intensifying slowly. The following day she attained maximum intensity of 80 kn. At 0600 on the 30th, the TAKAMATSU MARU reported 55-kn winds 160 mi northeast of Kathy.

Embedded in westerly flow, Kathy began to accelerate to the northeast and by the afternoon of February 1 had weakened to a tropical storm. Strong westerly shear and cooler temperatures rapidly stripped the storm of its tropical characteristics, and Kathy became extratropical late that day. This extratropical low later produced copious precipitation over the Hawaiian Islands with Wailua, Oahu, recording 18.81 in of rain during February 6 to 8.

MARIE

On April 1, a tropical disturbance was detected by satellite near 10°N, 140°E. The system drifted slowly southward for the next 2 days. At 0030 on the 3d, a formation alert was issued when synoptic data indicated the system had intensified to 25 kn. The system was upgraded to tropical storm Marie on the 3d when synoptic data confirmed aircraft reports of 35-kn winds.

Marie intensified and attained typhoon strength by 0600 on the 5th. Twelve hours later, the typhoon had acquired a 6-kn movement to the west-northwest and maintained 65-kn winds for the next 48 hr.

On the evening of the 7th (fig. 10) the typhoon once

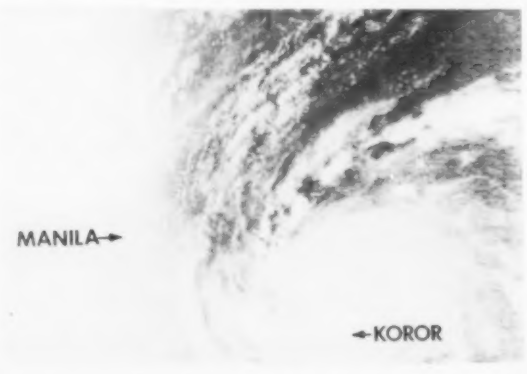


Figure 10.--Moonlight image of Marie near 70-kn intensity on April 7. DMSP Imagery.

again began to intensify. At 1500 Marie passed 40 mi north of Palau with peak gusts of 75 kn, and a minimum sea-level pressure of 993 mb was recorded at Koror. While no deaths or injuries were reported, damage of more than $4 million was incurred on the Palau Islands. Crop destruction was extensive as was damage to buildings and public utilities. As a result, Palau was declared a major disaster area.

On the 8th Marie turned northward and recurved. During the typhoon's westernmost position at 2100 on the 10th, the system reached its maximum intensity of 115 kn. The lowest sea-level pressure was 929 mb recorded by aircraft at 2031. Marie maintained 115-kn winds for 24 hr as she moved northeastward at 11 kn. By 1800 on the 11th, the storm began to weaken while accelerating on a northeasterly track. Two days later the final warning was issued as Marie became extratropical.

OLGA

Originally, Olga was tracked by satellite as a tropical disturbance moving southwestward and following the center of the upper-level anticyclone. After 1200 on May 12, a more climatological track toward the west-northwest was observed, but it was moving at only half the normal speed for this time of year. This movement along the southern edge of the subtropical ridge persisted through the afternoon of the 13th when Olga was upgraded to a tropical storm. Later that night satellite data indicated the presence of a second circulation 120 mi east of the storm's center. The original center dissipated by the 14th, and the convective energy consolidated around this second center. The relocated system then proceeded west-northwestward, while it slowly intensified and attained tropical storm intensity for the second time.

On the 18th, Olga began a counterclockwise loop and slowly intensified despite the unfavorable upper-level shear. On the 20th, Olga completed her loop and attained typhoon intensity. The storm then tracked toward the west at 6 kn and continued to intensify. Between aircraft reports at 0330 and 1947 on the 20th there was a 44-mb drop in central pressure from 978 to 934 mb, a rate of 2.7 mb per hr (fig. 11). With this rapid deepening, Olga made landfall on the east side of Luzon at 0000 on the 21st with winds estimated at 100 kn.

The small core of high winds subsided quickly after landfall. Olga's center meandered toward the southwest along the east coast of Luzon, passing near Baler Bay with 45-kn winds at storm center. Seeking the path of least resistance, Olga tracked through the lowlands of Luzon and exited the island through Lingayen Gulf on the 24th. During her slow journey across Luzon, Olga enhanced the southwest monsoon over southern Luzon, bringing rains in excess of 50 in at Cebu Point and perhaps higher at other areas. The resulting floods contributed to over 200 deaths and left thousands homeless. Olga dissipated to the west of Okinawa on the 27th as she was absorbed into a subtropical disturbance west of the island.

PAMELA

Pamela was the first supertyphoon of the season. Destined to become one of the more destructive storms of history, Pamela was first detected as a tropical disturbance on the morning of May 13. On the 14th aircraft indicated surface winds near 40 kn and a sea-level pressure of 998 mb; at 0600 the depression was upgraded to tropical storm Pamela.

The next morning satellite data showed Pamela moving toward the south-southeast. By 2200 Truk had a surface pressure of 997.9 mb and 30-kn northeasterly winds. Later that afternoon reports indicated destructive winds at Satawan Atoll. Reconnaissance aircraft observed an extensive area of 55- to 65-kn flight-level winds with surface winds estimated as high as 100 kn. Pamela at this time was a small, but intense typhoon (fig. 12). The maximum winds

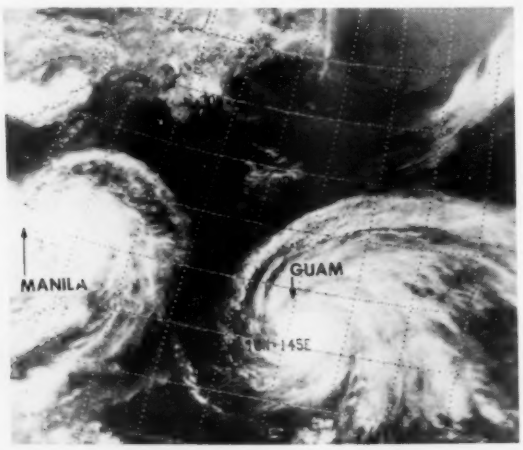


Figure 11.--Typhoon Olga (left) east of Luzon at 70 kn is deepening rapidly as typhoon Pamela moves toward Guam on May 20. NOAA-4 Imagery.

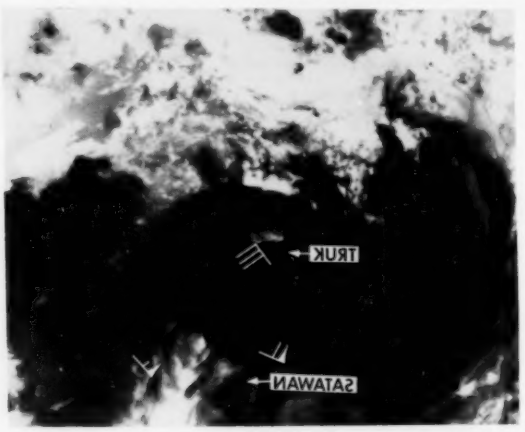


Figure 12.--Infrared photograph of Pamela with 65-kn winds while 75 mi southeast of Truk on May 16. Wind barbs are for 700 mb observed by reconnaissance aircraft. DMSP Imagery.

were located on the south side of the 150-mi diameter central dense overcast.

Pamela continued to intensify as she moved erratically at 3 to 6 kn, turning northwestward on the morning of the 17th. From the morning of the 16th until the morning of the 18th, Satawan Atoll continued to be buffeted with southwesterly and southerly surface winds of 50 to 55 kn. Damage was widespread, but no deaths were reported.

By the morning of the 18th Pamela had accelerated to 7 kn, passing within 50 mi of Truk where 40-kn winds were observed. At 0327 aircraft found maximum surface winds of 85 kn, a minimum pressure of 951 mb, and a circular eye 10 mi in diameter. From the afternoon of the 17th to the afternoon of the 18th, Truk recorded nearly 11 in of rain which initiated mud slides killing 10 persons. Massive damage was inflicted on crops.

From 0600 on the 18th to 0600 on the 19th, typhoon Pamela moved toward the northwest at an average speed of 9 kn, intensifying at a rate of 10 kn each 6 hr. At 1200 on the 19th, Pamela reached supertyphoon intensity of 130 kn with gusts to 160 kn (fig. 13) and maintained this intensity for 18 hr. At 2112 on the 19th, reconnaissance aircraft reported the minimum measured sea-level pressure at 921 mb. By the afternoon of the 20th, an eastward-moving, short-wave trough had created a weakness in the midtropospheric subtropical ridge north of Pamela. This, coupled with an elongated high-pressure cell east of the typhoon, forced Pamela to acquire the north-northwestward track which would bring it over Guam.

During the next 24 hr northeasterly winds on Guam slowly intensified as Pamela approached the island. At 0315 on the 21st, reconnaissance aircraft from the 54th Weather Reconnaissance Squadron, Andersen AFB, Guam, fixed the typhoon 30 mi southeast of the island. Less than 90 min later the northwestern edge of the eye was over the southeast coast of Guam.

The large, relatively calm eye, some 20 mi in diameter, required up to 3 hr to cross the center of the island (fig. 14). Both Andersen AFB and the National Weather Service (NWS) at Taguac continually experienced winds exceeding 50 kn as the eye passed south of these stations. Most installations which had wind indicators lost their anemometers prior to the peak winds. The maximum observed wind gust was 138 kn reported by the NWS Taguac at 0946 on the 21st. The minimum recorded surface pressure was 931.7 mb at NAS Brewer Field, some 5 mi northeast of the center. The lowest pressure of approximately 930 mb (indicated by aircraft and land stations) supports estimated peak sustained winds of 120 kn with gusts of 145 kn. Pamela's winds gusted as much as 80 kn between peak and lull in a matter of minutes, resulting in ex-

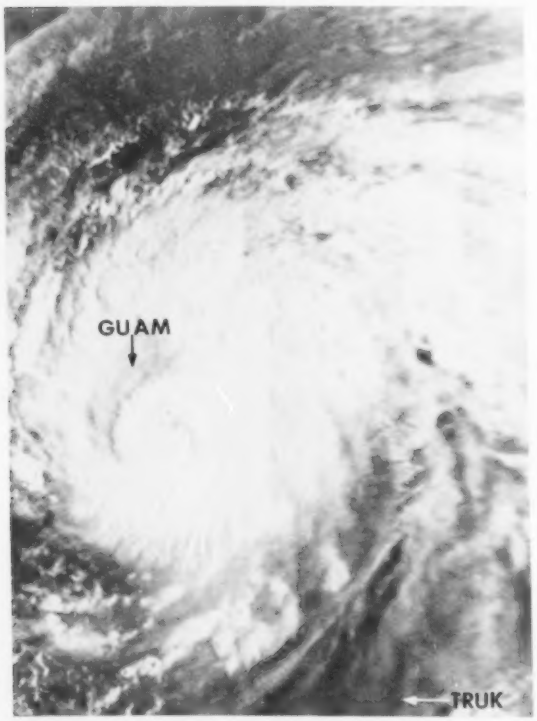


Figure 13.--Typhoon Pamela with 120-kn winds is only 65 mi southeast of Guam on May 20. DMSP Imagery.

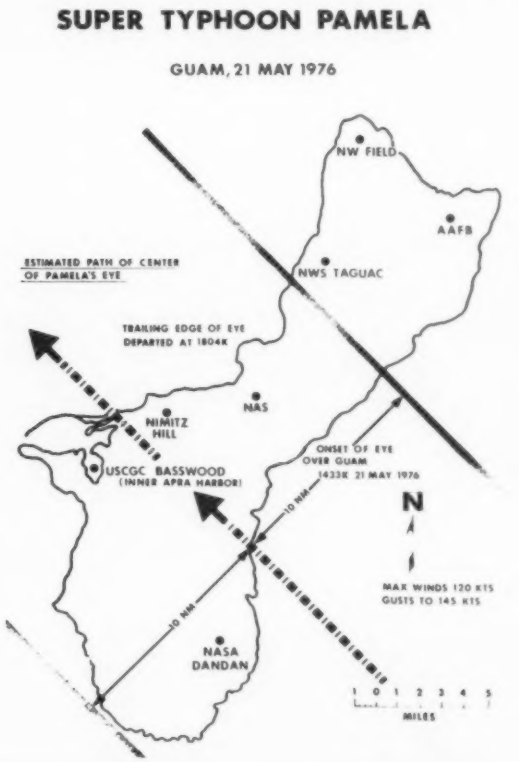


Figure 14.--Estimated path of the center of Pamela's eye as it crossed Guam from 0433 to 0804 on May 21.

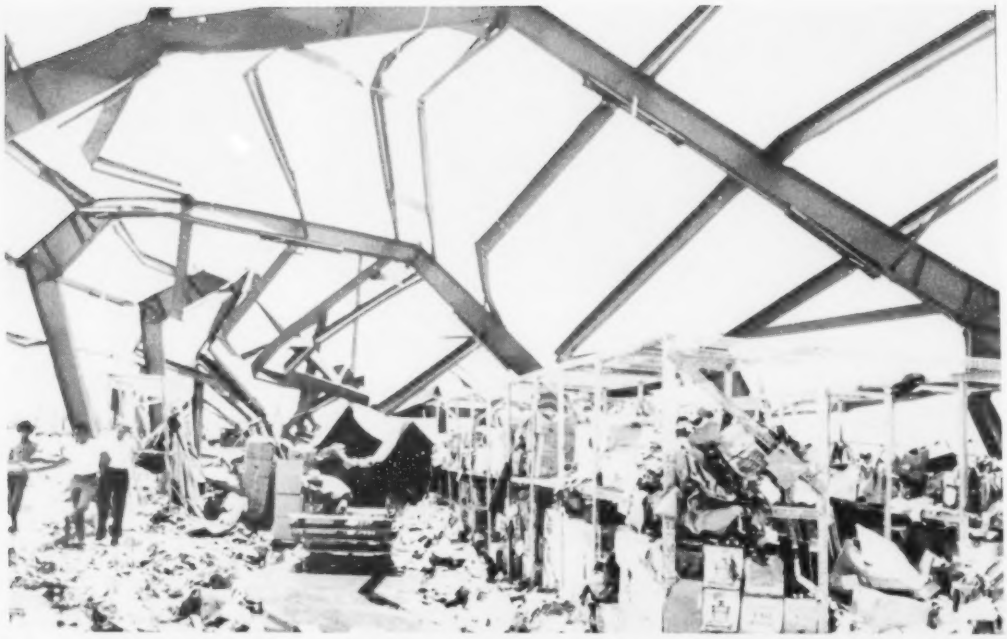


Figure 15.--The twisted steel skeleton of a once substantial warehouse attests to Pamela's destructive force. U.S. Navy Photograph.

Figure 16.--Destruction was widespread in the civilian community. Concrete structures fared well, but wooden houses, powerlines, and the telephone system were severely damaged. U.S. Navy Photograph.

Figure 17.--This long line at Andersen AFB, Guam, was representative of those throughout the island as people gathered for food, water, and other supplies. U.S. Navy Photograph.

Figure 18.--Two tugs at the U.S. Naval Station were grounded. The powerful winds and wave action severely affected the inner Apra Harbor. U.S. Navy Photograph.

tremely large pressure differences (60 to 70 lbs per sq ft) on windward and leeward sides. Few unreinforced structures were able to withstand the intermittent pressure and wrenching effects. NWS Taguac recorded 33 in of rain during Pamela's passage, with 27 in falling in a 24-hr period.

Although Pamela's winds were 25 kn weaker than those of typhoon Karen, which flattened Guam in November 1962, the slow 7-kn movement rendered Pamela more destructive (fig. 15). The 226-sq-mi island was buffeted by winds in excess of 100 kn for 6 hr, by winds of typhoon force for 18 hr, and by winds exceeding 50 kn for 30 hr. Despite extensive preparations, damage to civilian and military facilities was severe, exceeding $500 million (figs. 16 and 17). Ten small ships and tugs which had sought refuge in Apra Harbor were either sunk or run aground, and numerous other small craft were sunk or damaged (fig. 18). One ship, the U.S. Coast Guard cutter BASSWOOD, courageously rode out the storm anchored in Apra Harbor, where it recorded a peak gust of 120 kn and a minimum sea-level pressure of 933.1 mb.

Miraculously, only one death occurred on Guam due to Pamela's passage. This low loss of life was attributed to the timely and accurate forecasts issued on the storm.

After devastating Guam, Pamela maintained 120-kn intensity for an additional 36 hr and moved northwestward at an average speed of 10 kn. Saipan had gusts of 55 kn and 10 in of rain as the storm passed 120 mi west of the island.

On the morning of the 23d, Pamela, still packing winds of 115 kn, slowed to 8 kn and by evening passed through a weakness in the midtropospheric subtropical ridge, recurving to the northeast. At 2000 on the 24th, Pamela passed 15 mi east of Iwo Jima, blanketing the island with 75-kn winds. By the 25th the system had weakened to a tropical storm, and by the afternoon of the 26th Pamela had become extratropical.

RUBY

On the morning of June 23 satellite data indicated a disturbance had organized into a tropical depression about 450 mi southeast of Manila and was moving westward. Reconnaissance aircraft at 1205 indicated that the depression had attained tropical storm intensity; flight-level winds of 70 kn and a central pressure of 987 mb were reported. Radar reports from Catanduanes Island further indicated that tropical storm Ruby was moving northwestward. Late on the 23d, Ruby had intensified with an eye and surface winds in excess of 70 kn.

On the afternoon of the 25th, Ruby began her passage over central Luzon. Still tracking northwestward, she crossed the eastern coast 10 mi south of Cape Ildefonso with winds of 80 kn. Official reports of damage resulting from Ruby's passage were unavailable. However, Pacific Stars and Stripes reported in their July 4 issue that 16 persons in the province of Benguet were killed as a result of mud slides triggered by heavy rains.

Passage over the Philippines weakened Ruby to a tropical storm. On the morning of the 26th, she began to move northward, passing 35 mi east of Pratas Island on the 27th where 35-kn winds and a sea-level pressure of 985 mb were observed. By the morning of the 28th, satellite data indicated that Ruby had reintensified (fig. 19).

As Ruby traveled eastward through the Bashi Channel, radar reports from Kao-hsiung indicated eastward movement and intensification (fig. 20). Reconnaissance aircraft at 1600 July 1 recorded the lowest pressure, 934 mb, and indicated that typhoon Ruby was moving toward the northeast.

Ruby maintained typhoon intensity until the night of the 3d when she again moved into a hostile environ-

Figure 19.--Ruby (left) is near typhoon intensity 430 mi north-northwest of Manila on June 27. Typhoon Sally is about 800 mi to the east-southeast. DMSP Imagery.

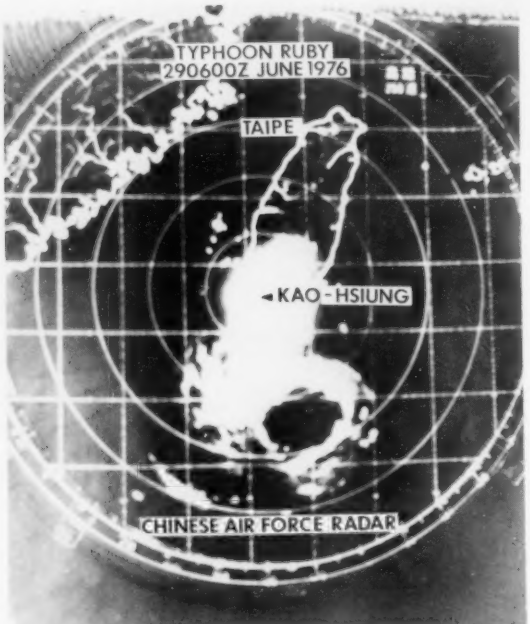


Figure 20.--A radar presentation of Ruby with 70-kn winds 125 mi south-southeast of Kao-hsiung, Taiwan, on June 29. Picture courtesy of Central Weather Bureau, Taipei, Taiwan, Republic of China.

ment. Meteorological satellite data at 2312 on the 3d indicated that Ruby had finally become extratropical after a 10-day trek.

SALLY

Sally was first detected on June 23d as a weak disturbance 210 mi south of Guam. The disturbance remained quasi-stationary as it slowly intensified. On the 24th the system intensified to 30 kn and began moving northwestward at 7 kn. Intensification was slow during the subsequent 30 hr. By the 26th Sally began more rapid intensification, attaining typhoon intensity by 1800 and maximum intensity of 115 kn 36 hr later (fig. 21). Reconnaissance aircraft reported a 40-mb drop in pressure (964 to 924 mb) from 0716 on the 27th to 0230 on the 28th.

Figure 21.--Typhoon Sally at point of recurvature with 100-kn winds 540 mi southeast of Okinawa on June 27. DMSP Imagery.

By 1200 on the 27th, Sally had slowed to 6 kn and had taken a more northward track. She moved slowly northward, then north-northeastward, as Ruby, some 820 mi to the west, attained typhoon force and began moving toward the east. By 1200 on the 29th the distance between the two typhoons had closed to 790 mi. Sally responded by recurving to the northeast. At 0000 on the 30th, the KAVALEROVO reported sustained 50-kn winds 120 mi northwest of the storm which still possessed 95-kn winds.

At 1800 on the 30th, Chichi Jima (40 mi northeast of Sally) reported southeasterly winds of 30 kn and a sea-level pressure of 980.5 mb. Twelve hours later the rapidly moving storm was 180 mi east-northeast of the island. On July 2 the system began to weaken rapidly and was extratropical on the 3d.

THERESE

Near the end of the first week in July a tropical

disturbance, moving slowly westward, was detected by satellite near 9°N, 160°E. On the 10th the disturbance intensified rapidly, and aircraft observed winds of tropical storm intensity. At 0000 on the 11th, the first warning was issued on tropical storm Therese with winds of 40 kn near the center. She continued to intensify while accelerating slowly on a west-northwesterly course. By 0000 on the 12th, Therese had reached typhoon intensity. At about 1200 explosive deepening began to occur. Reconnaissance aircraft indicated that from 0805 on the 12th until 0537 on the 13th the storm's central pressure plummeted 66 mb (fig. 22). Therese became the second supertyphoon of the season, attaining a minimum surface pressure of 903 mb and maximum winds of 135 kn at 0600 on the 13th. She maintained supertyphoon intensity for the next 18 hr, and at 2100 on the 13th passed 30 mi northeast of Saipan with 130-kn winds near the center. Saipan sustained only minor damage with observed winds estimated at 75 to 100 kn.

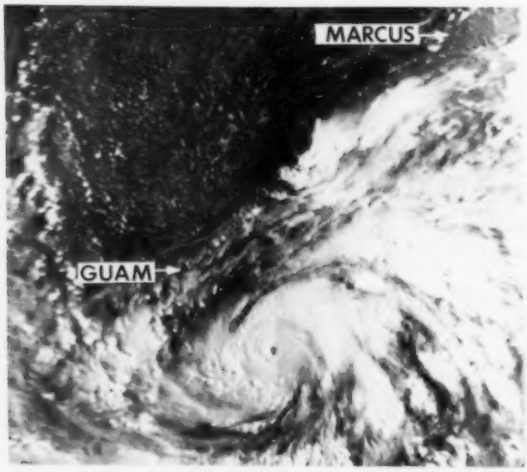


Figure 22.--Typhoon Therese at near 115-kn intensity late on July 12 just prior to explosive deepening to 903 mb on the 13th. DMSP Imagery.

Therese began to accelerate and slowly weaken as she tracked farther north. With 90-kn winds on the morning of the 17th, Therese passed 60 mi northeast of Okinawa, where 41-kn gusts were recorded at Kadena Airbase. Directly ahead of the storm, Tokuno-Shima was reporting 50-kn winds. At 1200 the island experienced eye passage with a recorded central pressure of 958 mb.

At 1200 on the 18th, Meshima reported sustained winds of 65 kn and minimum sea-level pressure of 971.2 mb. Shortly thereafter Therese passed 10 mi east of the island as the storm turned to the northeast toward the west coast of Kyushu. After crossing the coast, the storm continued to dissipate over the mountainous terrain. Prior to dissipation, Therese brought nearly 20 in of rain to the island of Kyushu. The storm flooded more than 1,000 homes and sank 12 ships. During the onslaught, 3 persons were killed, more than 1,300 were rendered homeless, and damage to crops was estimated in the millions of dollars.

ANITA

As early as July 18, the weak circulation which eventually developed into Anita was tracked by satellite. On the 22d Wilda and Anita were developing simultaneously.

As Anita continued to intensify, the size of the storm remained relatively small. Aircraft reconnaissance on the 23d found only a narrow band of strong winds near the storm's center. Anita continued to intensify, reaching a peak of 65 kn and a minimum sea-level pressure of 979 mb at 1200 on the 23d (fig. 23).

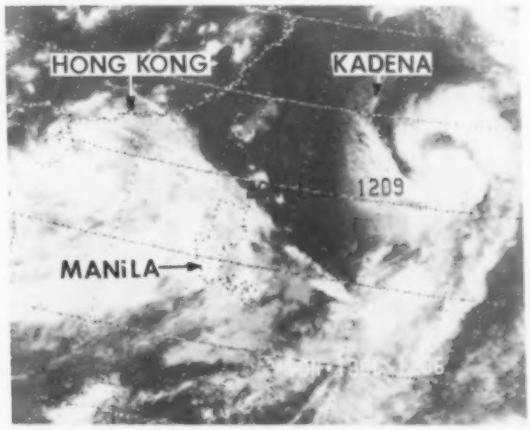


Figure 23.--Inverted infrared photograph of typhoon Anita at peak intensity 360 mi southeast of Kadena Airbase, Okinawa, on July 23. The cloud mass at the left is tropical storm Violet approaching the China coast. NOAA-4 Imagery.

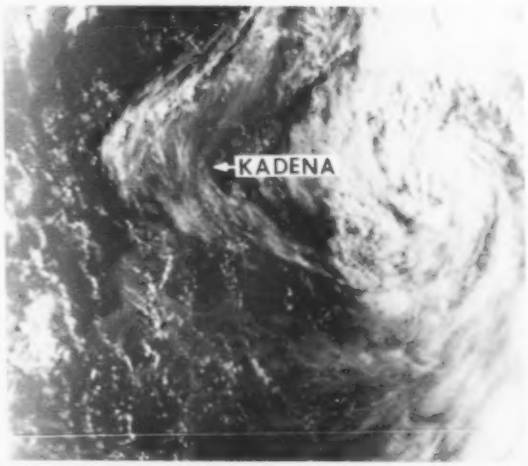


Figure 24.--Anita has fallen to 60-kn intensity 10 hr later at 2314 on the 23d 270 mi east of Kadena Airbase. DMSP Imagery.

About the time Anita attained typhoon intensity, she began to accelerate northward. Anita's typhoon intensity lasted only 12 hr. Satellite data at 2214 on the 23d indicated that the storm had lost most of its hard-core convection (fig. 24). Thus, Anita was downgraded to a tropical storm at 0000 on the 24th. The system continued to weaken, crossing western Kyushu late on the 24th with minimal tropical storm intensity. On the 25th, the remains of Anita entered the Sea of Japan and became extratropical at 0600 while moving northward at 14 kn.

BILLIE

On August 3, a tropical depression moved toward the northwest in the direction of Saipan. It passed over Saipan between 1700 and 1800 with 15-kn southwesterly winds, a sea-level pressure of 999.8 mb, and a 6-hr rainfall of 3.86 in. At 1800 the depression was designated tropical storm Billie.

The following morning the storm was tracking southwestward at 4 kn with 40-kn winds. Billie continued to slowly intensify as outflow in all but the northeast quadrant remained good.

During this period of erratic movement it appeared that Billie would be a threat to Guam. By the 6th, however, the upper low had moved considerably westward, eliminating its restricting influence on the tropical cyclone. Billie accelerated on a northwestward track and attained typhoon intensity by 1800 on the 5th.

Billie underwent explosive deepening during the night of the 6th. Reconnaissance aircraft at 1448 on the 6th and 0340 on the 7th indicated that during this period the eye temperature at 700 mb rose from 17°C to 26°C, and the central pressure fell 46 mb. The 914 mb reported at 0350 on the 7th was the minimum pressure attained by Billie. Maximum surface winds were estimated at 120 kn. At 0800 on the 7th, the TEGURA-SAN MARU encountered southwesterly winds of 50 kn and a minimum sea-level pressure of 992.3 mb while about 70 mi south-southeast of the center (fig. 25). At 1200 typhoon Billie reached her maximum intensity of 125 kn.

Billie moved into the southern Ryukyu Islands by 0000 on the 9th. Figure 26 illustrates surface observations from 0000 through 1000 on the 9th at the island stations of Miyako Jima and Ishigaki Shima. Miyako

Figure 25.--Typhoon Billie with an intensity of 115 kn while 300 mi southeast of Kadena Airbase on August 7. DMSP Imagery.

Jima reported its lowest sea-level pressure of 964.4 mb at 0400 while experiencing 44-kn sustained winds. Two hours later Ishigaki Shima reported a pressure of 952 mb and northwesterly winds of 45 kn. At about 0700 typhoon Billie passed over the northern tip of Ishigaki Shima with maximum winds estimated at 95 kn; 2 hr later the island reported 91-kn southwesterly winds gusting to 108 kn (fig. 27). Newspaper reports stated that "huge waves south of Japan drowned 41 fisherman and swimmers along Japan's Pacific coast."

After her destructive whirl through the Ryukyu's, Billie headed for Taipei, traveling westward at 14 kn.

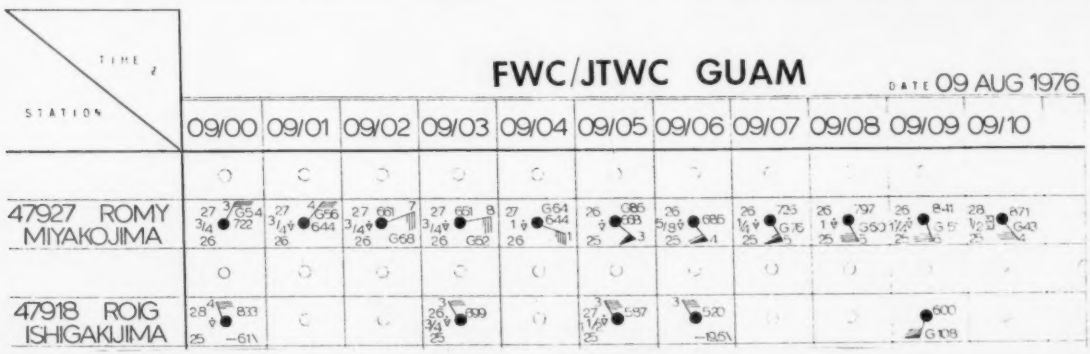


Figure 26.--Synoptic surface observations at Miyako Jima and Ishigaki Shima during the passage of typhoon Billie.

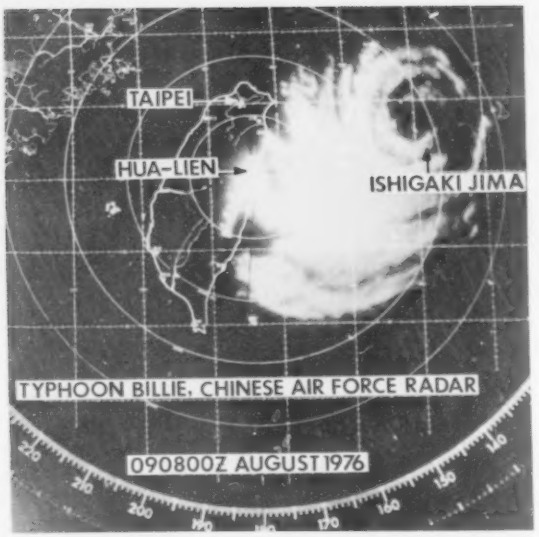


Figure 27.--A photograph of the radar scope on Taiwan as Billie pounds Ishigaki Shima with 90-kn winds on August 9. Photo courtesy of Central Weather Bureau, Taipei, Taiwan, Republic of China.

At 1200 on the 9th, Penkiayu reported northeasterly winds of 77 kn. Taipei International Airport experienced 30-kn sustained winds with gusts to 65 kn and a sea-level pressure of 957.3 mb at 1600; about 1 hr later the eye passed just south of Taipei. Billie's passage over Taiwan was highly destructive (fig. 28). Reports indicated 4 dead, 24 injured, and 8 missing. Nearly 1,000 homes were destroyed in the onslaught. Three ships were sunk and seven others, including the ALVA MAERSK, were severely damaged. Damage to power transmission facilities was estimated at $2,630,000.

Typhoon Billie exited Taiwan and moved toward the People's Republic of China on a west-northwestward track. By morning on the 10th, Billie had weakened to a tropical storm and slowed to 11 kn. At 0000 on the 10th, P'ing-t'an reported 60-kn winds from the north-northeast and a sea-level pressure of 981.2 mb. About 0300 Billie went ashore 25 mi southeast of P'ing-t'an. Within hours the storm dissipated over the rugged terrain of eastern China.

FRAN

This system was first detected on the afternoon of September 1 as an area of convective activity 200 mi northeast of Ponape. There was no significant development for 2 days. On the 3d satellite data indicated that the disturbance had strengthened, and it was upgraded to tropical storm Fran after reconnaissance

Figure 28.--Downtown Taipei after being lashed by 75-kn winds with typhoon Billie. Photo courtesy of Central Weather Bureau, Taipei, Taiwan, Republic of China.

aircraft at 0339 on the 4th recorded a central pressure of 997 mb. By 0000 on the 5th the storm was 90 mi south of Guam on a northwesterly track. Nine hours later Fran passed 20 mi west of Guam, where maximum sustained winds of 30 kn with gusts to 41 kn were reported. At 0245 on the 6th, aircraft reported maximum surface winds at 65 kn, and a circular eye 30 mi in diameter was observed. Based on this information and a recorded central pressure of 977 mb, tropical storm Fran was upgraded to a typhoon. She began to deepen explosively. On the 7th at 0307 reconnaissance aircraft recorded a central pressure of 916 mb and observed maximum surface winds estimated at 130 kn.

For 24 hr the upper tropospheric outflow remained unhindered, permitting the storm to maintain its maximum 130-kn supertyphoon intensity (fig. 29). On the 7th at 2109 the central pressure reached its lowest observed level of 913 mb.

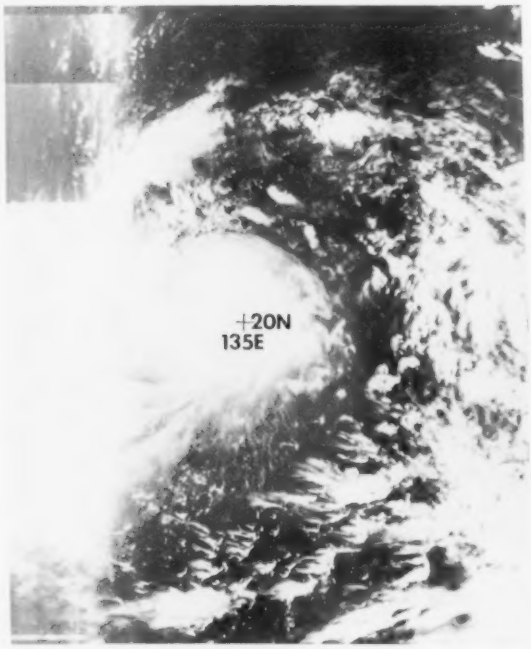


Figure 29.--A moonlight photograph of supertyphoon Fran with winds near 130 kn 450 mi southeast of Kadena Airbase on September 7. DMSP Imagery.

As Fran traveled through the Ryukyu Islands, she passed 60 mi east of Okinawa. Naha recorded a maximum sustained surface wind of 55 kn with gusts to 73 kn. Some damage was experienced at Kadena Airbase on Okinawa. By evening on the 10th Fran had slowed to 2 kn and during the subsequent 36 hr drifted on an erratic path toward the west. On the night of the 11th Fran began to accelerate northward.

During this period of slow, erratic movement, the storm's destructive winds caused several maritime mishaps. JICS ran aground at Tibjima, Minamata Bay, on September 12, and the KYOYU MARU reportedly broke in two in the Bungo Straits on the 11th.

On the afternoon of the 12th the storm accelerated and moved toward the north-northeast. Passing over Kyushu on the evening of the 12th, typhoon Fran weakened to tropical storm intensity. Twelve hours later as the storm traveled over the cooler Sea of Japan, it lost its tropical features becoming extratropical at 0600 on the 13th.

Typhoon Fran's slow movement through the Tokara Island group, over Kyushu, and into the Sea of Japan caused significant damage and loss of life. It was reported to be the most destructive tropical cyclone affecting Japan in the last 10 yr. The Japanese National Police Agency confirmed a total of 133 persons dead, 32 missing, and 227 injured as a result of Fran's torrential rains and strong winds. According to the Japan Times, damage to private and public facilities was estimated at approximately $572 million.

HOPE

Hope was first detected near 17°N, 157°E, on the morning of September 13 as a region of deep, but unorganized convection at the eastern edge of the intense monsoon trough. At 0600 on the 14th, the AMERICAN CHIEFTAIN, 125 mi northeast of Hope, reported 45-kn southeasterly winds and a minimum sea-level pressure of 998.7 mb. Some 200 mi south-southeast of the system, the AMERICAN LYNX reported southwesterly 40-kn winds and a minimum sea-level pressure of 998.8 mb. The first warning on tropical storm Hope was issued at 0702.

On the 15th Marcus Island reported maximum sustained surface winds of 54 kn and a minimum sea-level pressure of 988.6 mb as Hope passed 90 mi to the south-southwest. The typhoon attained its maximum

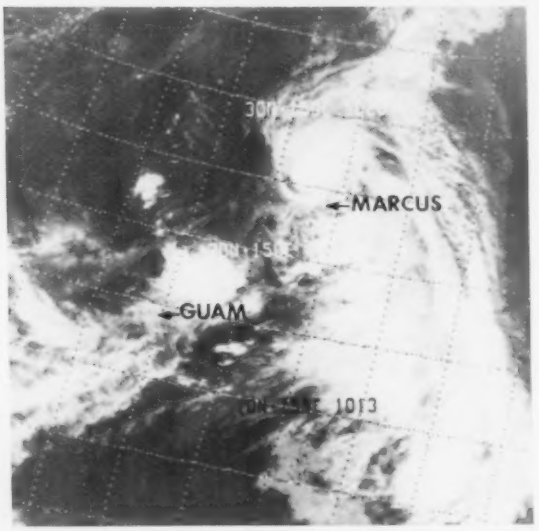


Figure 30.--An inverted infrared photograph of Hope 110 mi west-northwest of Marcus Island on September 15 as she approaches typhoon intensity. Remnants of tropical storm Georgia are northeast of Guam. NOAA-4 Imagery.

intensity of 70 kn at about 1800 on the 15th approximately 240 mi northwest of Marcus Island (fig. 30). During the morning of the 16th, typhoon Hope began to weaken as she slowed to 12 kn. Twenty-four hours later the storm had weakened to 45 kn and was moving toward the north-northeast at a speed in excess of 30 kn. The final warning was issued at 1800 on the 17th when strong shear, cooler sea surface temperatures, and incursion of cool air stripped Hope of her tropical nature.

IRIS

On September 13 satellites gave the first indication of what was to become the only typhoon of the year to originate in the South China Sea. By 0600 on the 15th, satellite and synoptic data indicated some intensification, and the tropical depression was upgraded to tropical storm Iris.

On the 17th at 0420 aircraft reconnaissance observed typhoon-strength surface winds 40 mi southeast of the storm's center and recorded a central pressure of 983 mb. At 1200 Pratas Island recorded winds of 40 kn and a sea-level pressure of 997.3 mb. Three hours later Iris passed 90 mi south-southwest of the island with maximum winds of 75 kn. At 2100 Pratas recorded a minimum sea-level pressure of 997.1 mb and winds of 33 kn. At 0600 on the 19th, Iris, still maintaining 75-kn winds, passed 35 mi south of Shan-Ch'uan-Tao where the station reported a sea-level pressure of 988.1 mb and winds of 60 kn (fig. 31). At 2100 Iris made landfall 30 mi north of Chancian on the Luichow Peninsula. The cyclone dissipated rapidly as it crossed the peninsula. Fifteen hours later it had weakened to a 35-kn tropical storm and entered the Gulf of Tonkin. The final warning was issued at 0600 on the 21st.

On the 18th Iris had passed 90 mi south of Hong Kong, where 68-kn winds were observed. Hong Kong newspaper reports indicated that more than a dozen people were injured by flying debris. Also on the 18th, 50 mi east of Pratas and 50 mi north of the storm, the CHIEH LEE, a 5,000-ton Panamanian freighter, sank. According to newspaper reports, 13 crewmen were rescued, while 4 were known dead and 11 others missing.

JOAN

Joan was initially observed on September 17 as a tropical disturbance with a weak surface cyclone centered near 13°N, 155°E. The disturbance intensified and became a depression on the 19th at 0600; at 1800 it was upgraded to tropical storm Joan, 325 mi south-southwest of Marcus Island.

By 0600 on the 21st, Joan attained typhoon intensity while at the midpoint of recurvature. Six hours later, typhoon Joan attained her peak intensity of 70 kn (fig. 32), and a distinct, well-defined eye was visible on satellite data with tightly wrapped convective bands surrounding the center. At 0000 on the 21st, Joan passed 125 mi west of Marcus Island, where 33-kn surface winds were observed. By the 22d, Joan had weakened slightly but still maintained typhoon intensity as she accelerated to 11 kn toward the northeast.

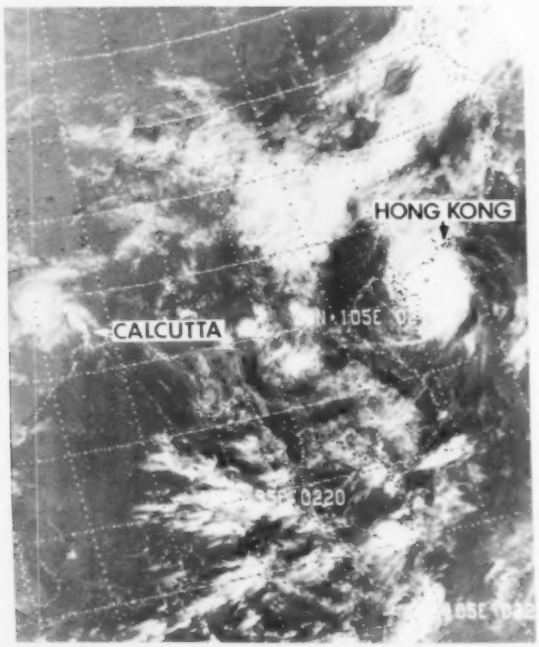


Figure 31.--Typhoon Iris (right) at 75-kn intensity while 110 mi southwest of Hong Kong on September 19. Tropical cyclone 23-76 is inland over India. NOAA-5 Imagery.

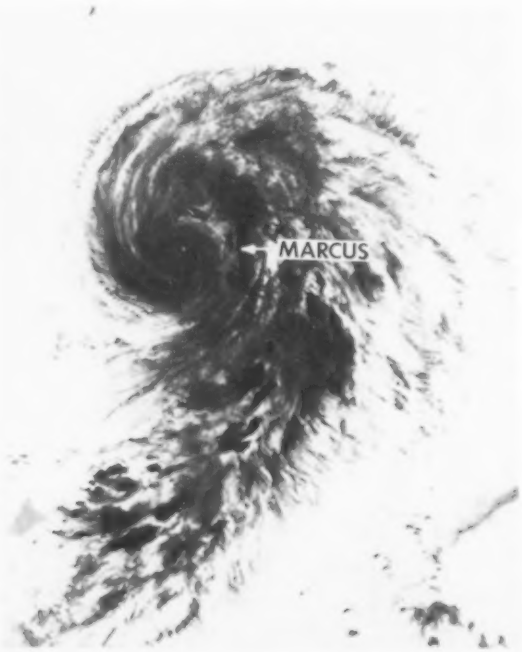


Figure 32.--An infrared image of typhoon Joan near her peak 70-kn intensity 130 mi west of Marcus Island on September 21. DMSP Imagery.

Joan continued to track northeastward accelerating to 31 kn by the 24th and becoming extratropical at 1200. The remains of typhoon Joan continued to disrupt shipping lanes in the western Pacific. At 1200 on the 24th, the GUELIO GRAF reported sustained winds of 65 kn and a sea-level pressure of 975 mb while sailing 60 mi east of the extratropical low.

LOUISE

Louise, the 14th and final typhoon of the season, was also the most intense of 1976. The disturbance that was to become Louise was first detected by satellite data on the morning of October 27 about 75 mi east of Truk. During the next 3 days the disturbance showed little intensification as it meandered through the northern Truk District. Late on the 29th the system began moving toward the west, and by the morning of the 30th satellite data indicated that it was intensifying. At 1800 the depression was upgraded to tropical storm Louise. At 0311 on November 1, aircraft observed 70-kn flight-level winds and found that the central pressure had fallen to 976 mb. At 0600 Louise was upgraded to a typhoon while 100 mi northwest of Ulithi Atoll. On the afternoon of the 1st Louise acquired a northwesterly track. Almost simultaneously, the typhoon commenced more rapid deepening, attaining 105-kn winds by the next morning. From 0311 on the 1st to 0310 on the 2d, reconnaissance aircraft indicated a fall in the central pressure of 43 mb. Further deepening to 905 mb occurred by 1435 on the 2d.

During early morning on the 3d supertyphoon Louise attained maximum intensity of 140 kn, which she maintained for nearly 36 hr (fig. 33). The lowest recorded pressure was 895 mb observed by aircraft at 0830 on the 3d. From 0000 on the 4th until 1800 on the 6th, Louise weakened at an unusually slow rate of 5 kn per 6 hr. Late on the afternoon of the 5th, Louise had weakened to 115 kn and began to accelerate toward the northeast.

At 0300 on the 6th, Minamidaito Jima, 40 mi north-northeast of Louise, reported east-northeasterly winds of 40 kn and a sea-level pressure of 984.8 mb. Two hours later the storm passed 15 mi southeast of the island with maximum winds estimated near 95 kn. By the 7th, cooler sea surface temperatures and very strong vertical shear were taking their toll as Louise moved north of 30°N. Reconnaissance aircraft at 0359 indicated that Louise was rapidly losing her tropical characteristics and becoming extratropical. The Airborne Reconnaissance Weather Officer also observed

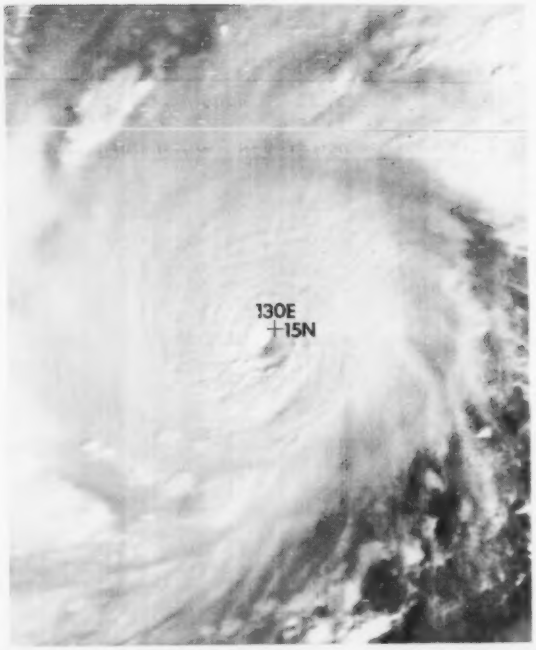


Figure 33. --Supertyphoon Louise 500 mi east of Manila late on November 2. About 9 hr later, she reached minimum pressure of 895 mb with 100-kn winds. DMSP Imagery.

that the lower half of the wall cloud was "rotating rapidly," a phenomenon sometimes reported when a storm is becoming extratropical.

As an extratropical system, the remains of Louise moved northward to combine with another surface low. The resulting system deepened to 947 mb by the 10th and became one of the most severe extratropical storms of the year, ultimately producing surf in excess of 30 ft in the Hawaiian Islands.

ACKNOWLEDGMENT

The Editor expresses his appreciation for the excellent cooperation of the Joint Typhoon Warning Center in supplying the information on which this article is based, the track charts, and photographs.

THE MARINERS WEATHER LOG WELCOMES ARTICLES AND LETTERS FROM MARINERS RELATING TO METEOROLOGY AND OCEANOGRAPHY, INCLUDING THEIR EFFECTS ON SHIP OPERATIONS.

CENTRAL NORTH PACIFIC TROPICAL CYCLONES, 1976

Extracted from report submitted by Meteorologist in Charge, NWS Forecast Office, Honolulu, Hawaii.

Hurricane Kate, the only hurricane to develop in the central Pacific during 1976, posed a threat to the Hawaiian Islands before she veered northwestward about a day's distance from the island of Hawaii. Seas generated by the hurricane caused surf up to 15 ft along the northern and eastern shores of Hawaii, Maui, and Oahu, but no significant damage was reported.

The storm which was later named Kate was spawned on September 20 in the usually absent central North Pacific near-equatorial trough. Other weak vortices were observed in this trough during the life of Kate but did not develop.

The Central Pacific Hurricane Center issued the first bulletin on the morning of the 21st. The GAMZAT TSADSA reported 30-kn southwesterly winds 150 mi southwest of the center of the tropical depression.

The depression's previous northwesterly track stopped on the morning of the 22d, and the storm gradually intensified, becoming hurricane Kate on the morning of the 24th very near its position of 48 hr earlier. Kate then slowly traveled westward for a day before sharply veering north-northwestward (fig. 34).

On the evening of the 25th, the JALAT YOTI was about 120 mi south of Kate with 25-kn westerly winds, indicating that the strong winds in Kate were tightly wound near her center. Kate attained maximum winds of 85 kn on the afternoon of the 26th about 600 mi east-southeast of Hawaii (fig. 35). She did not appear to be an immediate threat to the islands. However, by the next day she had turned northwestward and on the morning of the 28th was positioned only 330 mi due east of Hawaii. At this time it was expected that Kate would pass 150 mi northeast of the island.

During the 28th Kate veered slightly to the right of her expected path and passed harmlessly 240 mi east-northeast of Hilo, Hawaii, while she gradually weakened (fig. 36). Kate finally turned north as a weak tropical storm and ended her career near 27°N, 154°W, as the upper-air westerlies sheared her clouds and circulation.

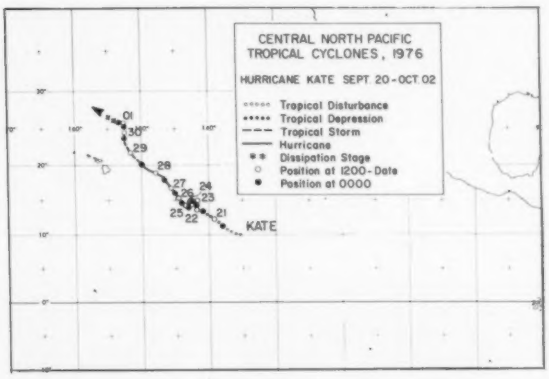


Figure 34. --Track of hurricane Kate.

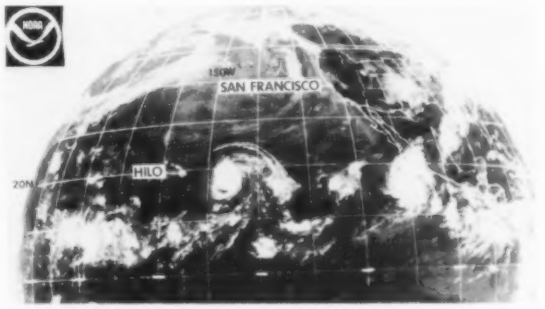


Figure 35. --Hurricane Kate in the center has 80-kn winds 550 mi east-southeast of Hilo, Hawaii. Hurricane Liza is paralleling the coast of Mexico on September 27. SMS-2 Imagery.

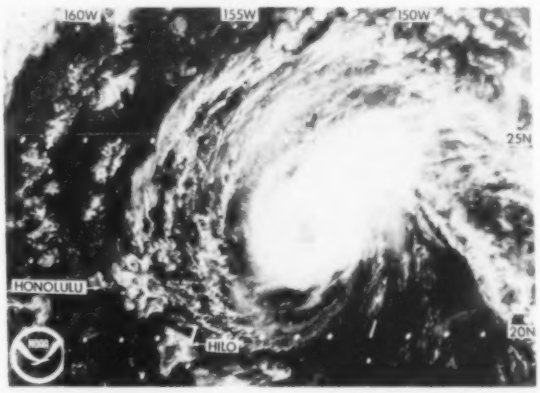


Figure 36. --An enlarged image of Kate with 55-kn winds 230 mi northeast of Honolulu on September 29. SMS-2 Imagery.

Mariners Weather Log

WORLD OF TROPICAL CYCLONES: SOUTH INDIAN OCEAN

Dick DeAngelis
Environmental Data Service, NOAA
Washington, D.C.

The UT EATIS prepared to battle the unknown. Somewhere to the north, in the narrow confines of the Mozambique Channel, lurked tropical cyclone Georgette. On the night of January 18, 1968, her exact position and future movement were uncertain. Hatches battened, the 2,500-ton tanker put into the wind and sea by sailing eastward in an attempt to circumnavigate the center without getting trapped against the lee shore. During the night, the storm intensified. According to the Italian freighter's log on the 19th: "The ship continued to roll and pitch heavily with the furious racing of the screw shaking the vessel and the sea flooding the deck." Winds of 100 kn beat at the ship. Torrential rains interlaced with spray reduced visibility to near zero. She was unable to estimate her position and was soon out of control.

Although Georgette was intense, she was not unusual. She was not even the most potent storm of the 1967-68 season. Those honors went to Monique (Monica), who was soon to become the most intense storm on record in the South Indian Ocean.

About 4 of 11 tropical cyclones reach hurricane strength in an average season in these waters, which extend westward from 100°E (table 4). The season runs from December through April, although storms can form in any month. More than 75 percent of these develop during January, February, and March.

Table 4.--Average monthly tropical storm and hurricane occurrences, South Indian Ocean, 1939-69

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Tropical storms	2.0	2.2	1.7	0.6	0.2	*	*	*	*	0.3	0.3	0.8	7.4
Hurricanes	1.3	1.1	0.8	0.4	*	*	*	*	*	*	*	0.5	3.8
Tropical storms and hurricanes	3.2	3.3	2.5	1.1	0.2	*	*	*	*	0.3	0.4	1.4	11.2

*Less than .05

Shipping in this region is concentrated along the east coast of Africa, a route sometimes referred to as the "floating pipeline." And in the Mozambique Channel where sea room and options are limited, the threat from a cyclone increases dramatically.

The UT EATIS was in just such a fix. As stated in her log: "There was no possibility of taking any evasive action in such conditions--the gravity of the situation was explained to the Chief Engineer who was asked to keep maximum power available. Eventually, with maximum power, the ship still rolled 40° with heavy pitching and vibration from the screw. By 1000 [on the 19th] it was no longer possible to maintain this new course [110°]." After an all day battle, conditions finally began to ease during the early morning hours of the 20th. It was another day before the Captain could survey the damage. One heavy truck had been swept overboard, while several had broken loose and collided. Below deck, sweat and water had taken their toll, but overall the ship had come through in good shape.

Tropical cyclones of hurricane intensity are more common east of the Malagasy Republic than they are in the Mozambique Channel. The center of hurricane activity lies between the Mascarene Islands, the Seychelle Islands and the Malagasy Republic. This is where Monique struck in March 1968. Her winds were devastating in the Mascarene Islands where Le Marechal, Rodrigues, reported 150-kn gusts along with a 933-mb pressure. The highest mean wind over a 1-hr period was 104 kn. Hurricanes are most likely during January, February, and March, although they are not restricted to these months. Maud, one of the largest cyclones on record, was an April storm (1962). Her gales extended out 300 mi, while hurricane-force winds blew out to 150 mi. Rodrigues, within 60 mi of her center, recorded a 955-mb pressure as winds gusted to 110 kn. Earlier that same season, Jenny, a small, fast moving storm, brought a 954-mb pressure with 118-kn gusts to Reunion and 127-kn gusts to Port Louis, Mauritius. Mauritius was hit even harder back in February 1960 when Carol generated 138-kn gusts at Medina, and pressure fell to 942.6 mb, with 128-kn gusts at Pamplemousses.

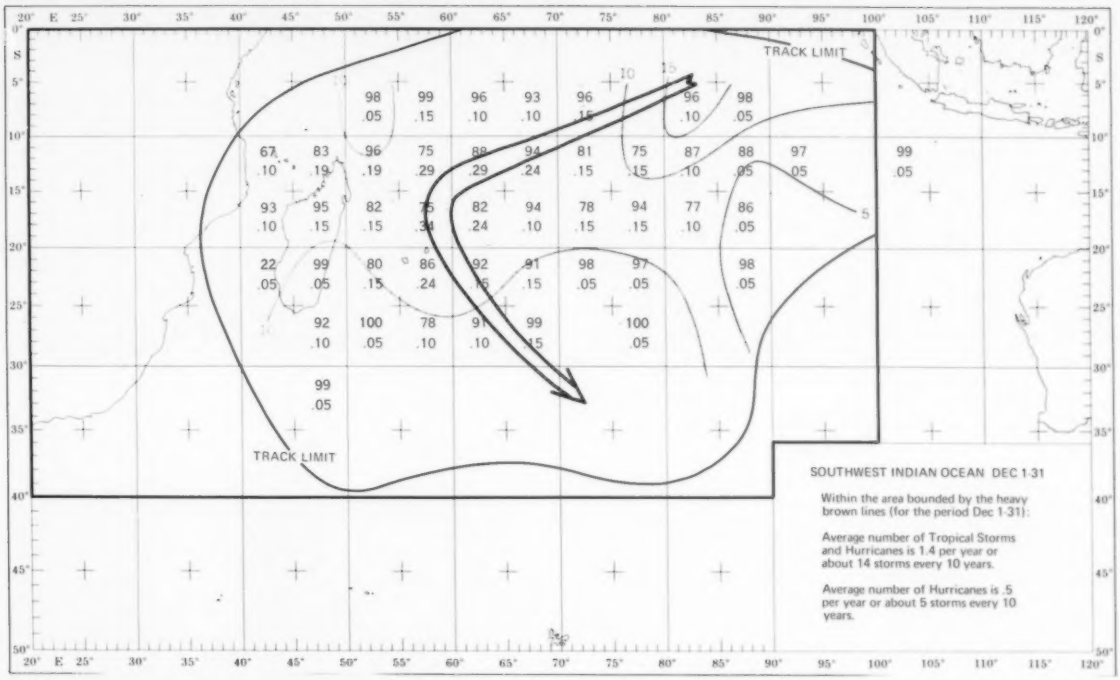
Despite the strong winds frequently generated by these tropical cyclones, they are most famous for record-breaking torrential rains.

The world's 24-hr rainfall record was set on Reunion Island on March 15-16, 1952. At Cilaos, in the central part of the island, a tropical cyclone dumped 73.62 in of rain. This is more than most cities in the United States receive in a year. The 12-hr world record of 52.76 in was set at Belouve, Reunion, in 1964. Reunion is about 30 mi by 40 mi and mountainous, with some elevations above 10,000 ft. Its steep slopes and rapidly narrowing valleys are ideal for producing heavy rainfall when winds favor upslope and upvalley motion. Belouve and Cilaos are at elevations in the 4,000- to 5,000-ft range. Table 5 shows some extraordinary rainfall that has occurred on Reunion.

Table 5.--Some extraordinary rainfall maxima at Reunion

Station:	Aurere		Belouve		Cilaos	
Lat. and long.:	21°00'S, 55°26'E		21°03'S, 55°33'E		21°07'S, 55°29'E	
Elevation:	940 m (3,084 ft)		1,500 m (4,921 ft)		1,200 m (3,937 ft)	
Duration (days)	Amount (in)	Date	Amount (in)	Date	Amount (in)	Date
1	62.33	4/7-8/58	66.49	2/27-28/64	73.62	3/15-16/52
2	97.12	4/7-9/58	95.09	2/27-29/64	98.42	3/15-17/52
3	123.21	4/6-9/58	105.90	2/26-29/64	127.56	3/15-18/52
4	134.74	4/5-9/58	109.50	2/26-3/1/64	137.95	3/14-18/52
5	136.83	4/4-9/58	110.22	2/25-3/1/64	151.73	3/13-18/52
6	136.83	4/4-9/58	110.58	2/24-3/1/64	159.65	3/13-19/52
7	136.83	4/4-9/58	112.04	2/26-3/4/64	161.81	3/12-19/52
8	136.83	4/4-9/58	118.54	2/26-3/5/64	162.59	3/11-19/52

South Indian tropical cyclones usually form in the Intertropical Convergence Zone (ITCZ) or just poleward of the low-level equatorial trough. The ITCZ and the trough migrate poleward in early summer and


TRACK LIMIT
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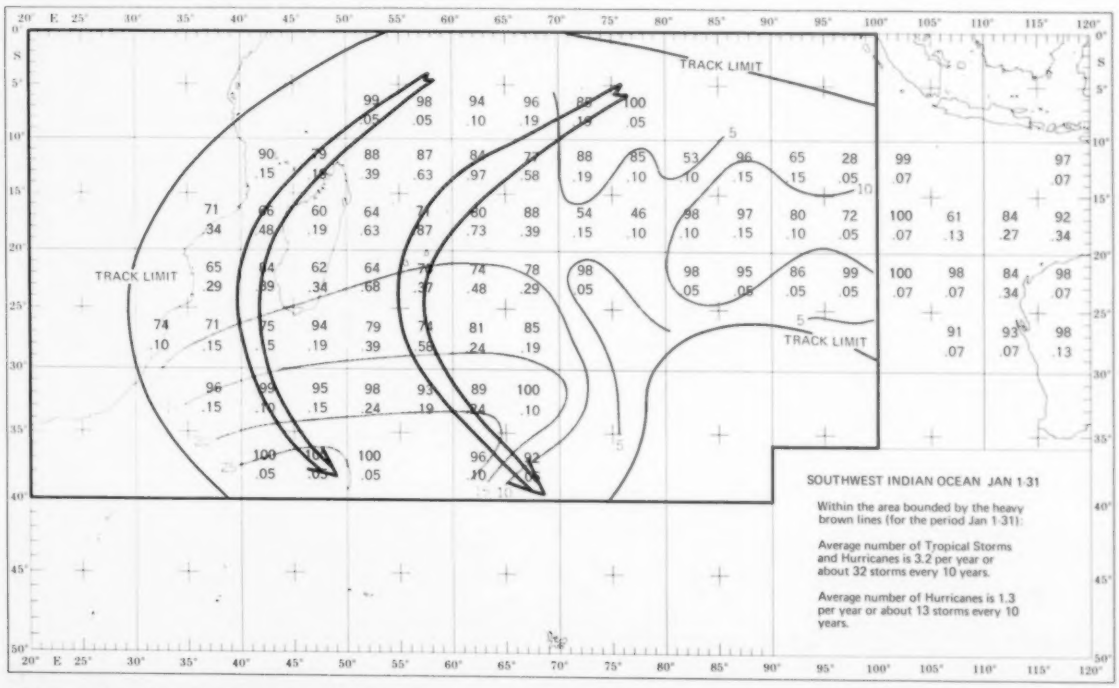
SOUTHWEST INDIAN OCEAN DEC 1-31
Within the area bounded by the heavy brown lines (for the period Dec 1-31):
Average number of Tropical Storms and Hurricanes is 1.4 per year or about 14 storms every 10 years.
Average number of Hurricanes is .5 per year or about 5 storms every 10 years.

Figure 37.--Arrows show preferred storm track. Arrow width is proportional to the storm frequency within the ocean basin and the time period for each chart. Isolines show the average storm speed (scalar) in kn. The top value for each 5° square is the constancy. The bottom value is the average number of tropical storms and hurricanes per time period per 5° square.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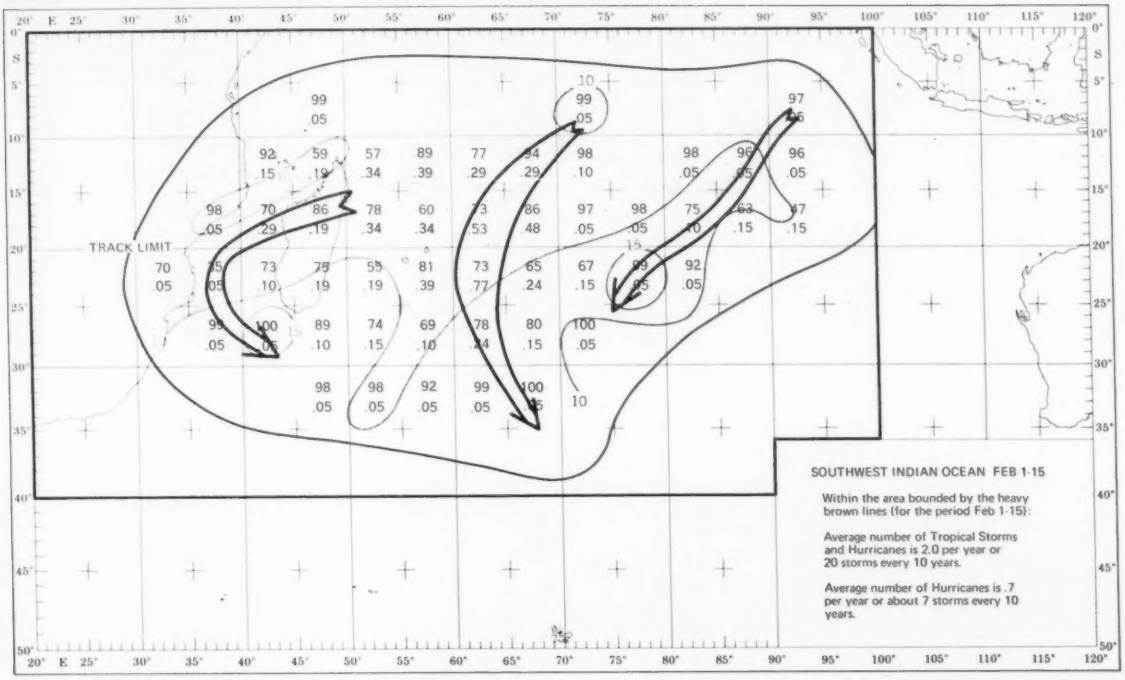
SOUTHWEST INDIAN OCEAN JAN 1-31
Within the area bounded by the heavy brown lines (for the period Jan 1-31):
Average number of Tropical Storms and Hurricanes is 3.2 per year or about 32 storms every 10 years.
Average number of Hurricanes is 1.3 per year or about 13 storms every 10 years.

Figure 38.--Arrows show preferred storm track. Arrow width is proportional to the storm frequency within the ocean basin and the time period for each chart. Isolines show the average storm speed (scalar) in kn. The top value for each 5° square is the constancy. The bottom value is the average number of tropical storms and hurricanes per time period per 5° square.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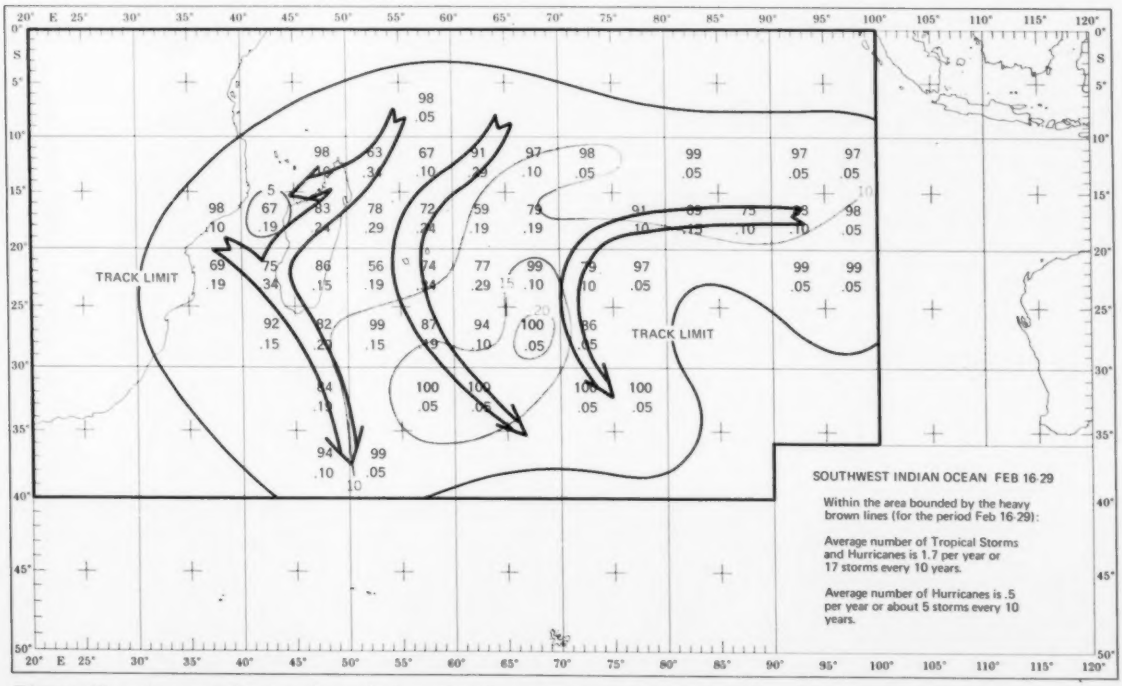
SOUTHWEST INDIAN OCEAN FEB 1-15
Within the area bounded by the heavy brown lines (for the period Feb 1-15):
Average number of Tropical Storms and Hurricanes is 2.0 per year or 20 storms every 10 years.
Average number of Hurricanes is .7 per year or about 7 storms every 10 years.

Figure 39.--Arrows show preferred storm track. Arrow width is proportional to the storm frequency within the ocean basin and the time period for each chart. Isolines show the average storm speed (scalar) in kn. The top value for each 5° square is the constancy. The bottom value is the average number of tropical storms and hurricanes per time period per 5° square.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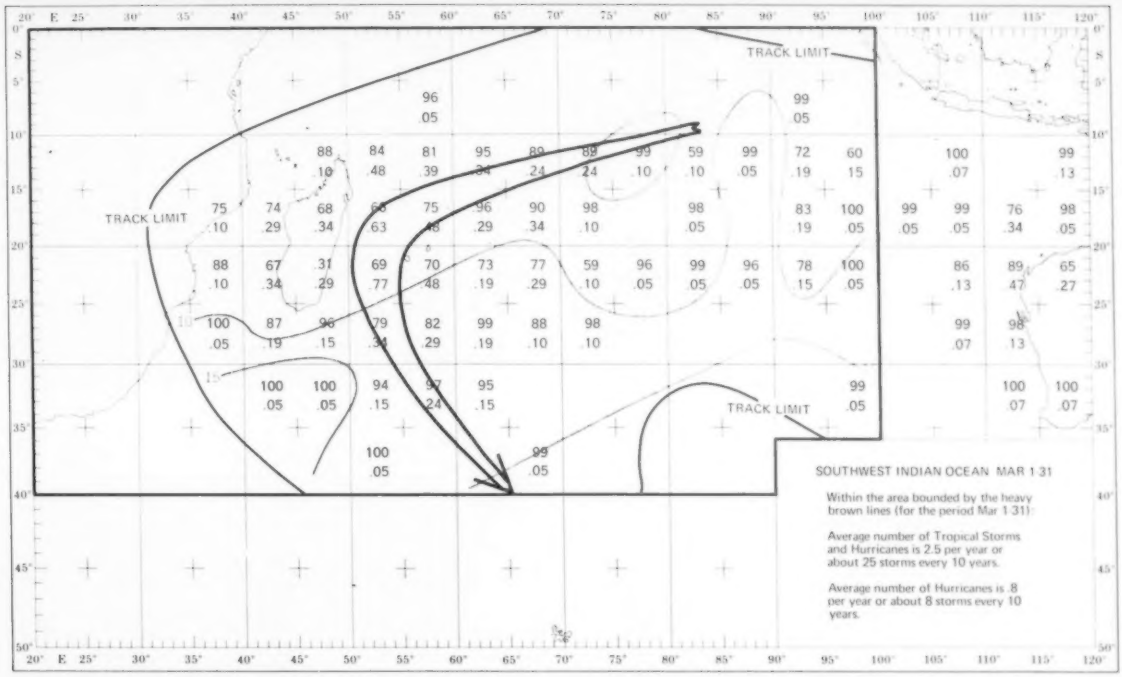
SOUTHWEST INDIAN OCEAN FEB 16-29
Within the area bounded by the heavy brown lines (for the period Feb 16-29):
Average number of Tropical Storms and Hurricanes is 1.7 per year or 17 storms every 10 years.
Average number of Hurricanes is .5 per year or about 5 storms every 10 years.

Figure 40.--Arrows show preferred storm track. Arrow width is proportional to the storm frequency within the ocean basin and the time period for each chart. Isolines show the average storm speed (scalar) in kn. The top value for each 5° square is the constancy. The bottom value is the average number of tropical storms and hurricanes per time period per 5° square.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SOUTHWEST INDIAN OCEAN MAR 1-31
Within the area bounded by the heavy brown lines (for the period Mar 1-31):
Average number of Tropical Storms and Hurricanes is 2.5 per year or about 25 storms every 10 years.
Average number of Hurricanes is .8 per year or about 8 storms every 10 years.

Figure 41.--Arrows show preferred storm track. Arrow width is proportional to the storm frequency within the ocean basin and the time period for each chart. Isolines show the average storm speed (scalar) in kn. The top value for each 5° square is the constancy. The bottom value is the average number of tropical storms and hurricanes per time period per 5° square.

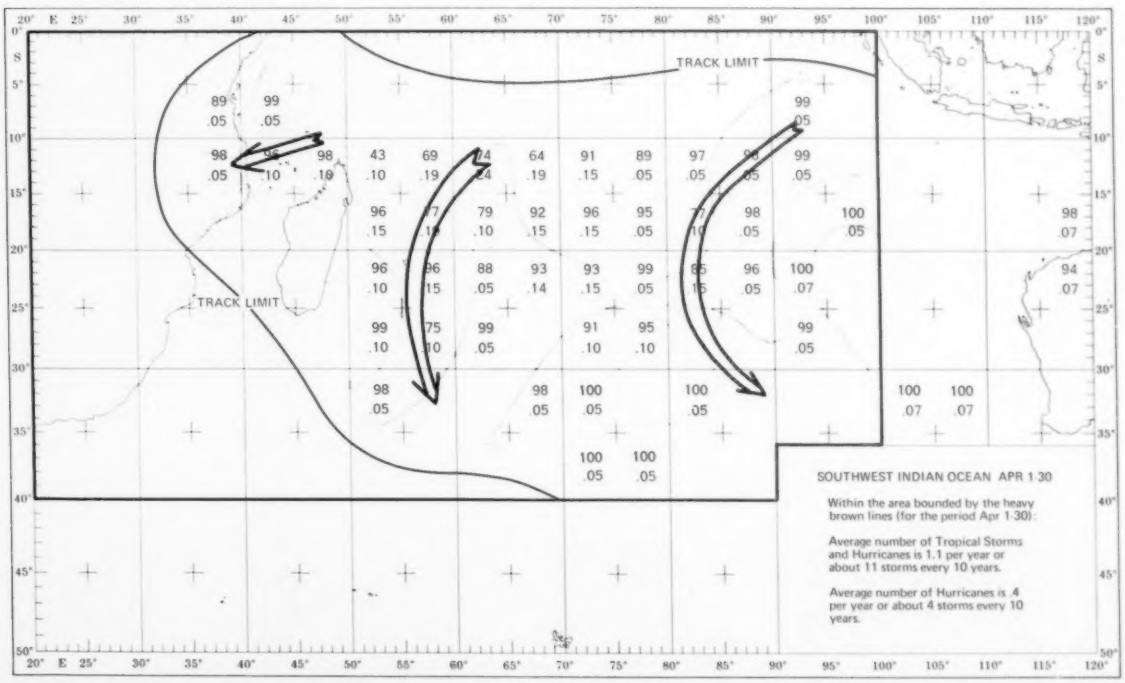

TRACK LIMIT
TRACK LIMIT
SOUTHWEST INDIAN OCEAN APR 1-30
Within the area bounded by the heavy brown lines (for the period Apr 1-30):
Average number of Tropical Storms and Hurricanes is 1.1 per year or about 11 storms every 10 years.
Average number of Hurricanes is .4 per year or about 4 storms every 10 years.

Figure 42.--Arrows show preferred storm track. Arrow width is proportional to the storm frequency within the ocean basin and the time period for each chart. Isolines show the average storm speed (scalar) in kn. The top value for each 5° square is the constancy. The bottom value is the average number of tropical storms and hurricanes per time period per 5° square.

toward the Equator late in the season. They are usually found between 2° to 5°S in October and May and between 12° to 15°S by February. In the west they extend into the Mozambique Channel during the midsummer months. The spawning grounds for tropical cyclones migrate with these features. These grounds are less restricted longitudinally. Early- and late-season storms tend to form between about 55° and 90°E, while from December through March the area extends from the African coast to east of 100°E.

After forming, tropical cyclones tend to move on a southwesterly through westerly course at about 5 to 10 kn. Some continue until landfall over the Malagasy Republic or Africa. Most, however, gradually turn southward then southeastward and accelerate into higher latitudes at speeds of 15 to 30 kn. Early- and late-season storms tend to recurve between 15° and 20°S, while midseason cyclones recurve between 20° and 30°S.

Figures 37 through 42 show the seasonal variation of tropical cyclone activity and average paths in the South Indian Ocean. These tracks represent smoothed general tracks. Individual storm movements are much more complex. The figures were obtained from the U.S. Navy's Mariners Worldwide Climatic Guide to Tropical Storms at Sea by Crutcher and Quayle.

For each 5° square there are two numbers on the charts. Constancy is the top value and is a measure of confidence in direction persistencies; i.e., when the constancy is high (90 to 100), there is a high likelihood that a storm will continue in the same general direction for 12 hr. As the constancy decreases, confidence that a storm will remain on course decreases. Constancy, as a confidence measure, is directly related to the number of storms used to determine the figure. The bottom number is the average number of storms per year for the time period of that chart. Multiplication of this number by 10 or by 100 gives the approximate average number of storms per 10 yr or 100 yr, respectively. From these charts the mariner can get a feeling for the frequency and general movement of South Indian tropical cyclones. However, only through experience can one appreciate their power.

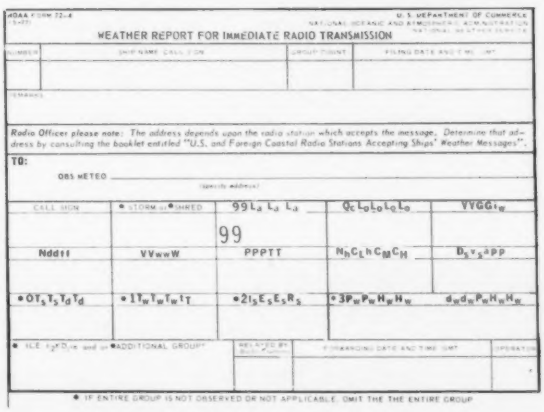
Both the mariner and the landlover in this region have a healthy regard for this power. Father Smith, who established an Agricultural Training Farm at Marechal, Rodrigues, recalls the visit from Monique: "By Saturday morning Monique had come and gone; I read in a French met magazine that she was the strongest ever recorded in the Indian Ocean. It was our anemometer which had the doubtful honour of doing the recording! On Friday morning 29th, I went up the hill to change the anemometer sheet and was bowled over twice by the wind, finishing up on all fours. I went into the lee of the concrete building hoping to get a breath and was intensely alarmed to find that I could not breathe at all! Like a fish on the bottom of a boat. Kneeling down I had to push my head well down between my thighs before I could get a mouthful of air. A funny feeling I can tell you. The gusts were well over 90 kn even then!"

Hints to the Observer

MARINE WEATHER OBSERVING FORMS

The National Weather Service (NWS) is attempting to simplify and reduce the time necessary for weather observing by volunteer shipboard observers. To accomplish this, several changes to the marine observing forms and aids have already been made and more are planned. An explanation of what has been done and what is planned follows.

In 1973 the NWS revised its Weather Report for Immediate Radio Transmission (NOAA Form 72-4)(fig. 43) based on an excellent critique by Trever J. Constable, the radio electronics officer aboard the HAWAIIAN ENTERPRISE. Since then, the form has been revised several additional times as experience with the form increased. The latest revision incorporates changes needed to lessen common problems in completing the form. The new form lists the ship name followed by the radio call sign. A separate line for remarks has been added for the radio officer because a review of completed forms received from ships demonstrated a need for this feature. The preprinted WASH DC heading has been removed since a significant number of ship weather reports are transmitted to other addresses. To insure that every report is properly


NOAA FORM 72-4 (5-67) — U.S. DEPARTMENT OF COMMERCE

WEATHER REPORT FOR IMMEDIATE RADIO TRANSMISSION

NUMBER | SHIP NAME CALL SIGN | GROUP COUNT | FILING DATE AND TIME GMT

REMARKS

Radio Officer please note: The address depends upon the radio station which accepts the message. Determine that address by consulting the booklet entitled "U.S. and Foreign Coastal Radio Stations Accepting Ships' Weather Messages".

TO:

OBS METEO _____ (specify address)

CALL SIGN	• STORM or • MINED	99 $L_a L_a L_a$	$Q_c L_o L_o L_o L_o$	VVGGi_w
		99		
Nddff	VVwwW	PPPTT	$N_h C_L h C_M C_H$	$B_s s_s$APP
• $0T_s T_s T_g T_d$	• $1T_w T_w T_w T_T$	• $2I_s E_s E_s R_s$	• $3P_w P_w H_w H_w H_w$	$d_w d_w P_w H_w H_w$
• ICE $1s'D_i s_i$ and/or	• ADDITIONAL GROUP	RELAYED BY (Station)	FORWARDING DATE AND TIME GMT	OPERATOR

• IF ENTIRE GROUP IS NOT OBSERVED OR NOT APPLICABLE, OMIT THE THE ENTIRE GROUP

Figure 43.--Weather Report for Immediate Radio Transmission (NOAA Form 72-4).

identified and credited to the correct vessel, the ship call sign has been included as a group in the transmitted message. Also added is the option to send weather using the international SHRED code (an abbreviated version of the standard ship code).

Some groups on the new form are marked with an asterisk (*) to remind the observer that if the entire group is not reportable, it should be left blank rather than entering solidi (/) as in the case of mandatory groups. Solidi should continue to be used to represent missing or unobserved elements within the groups of the message. Wind wave and swell groups are a single encoded group (i.e., $3P_wP_wH_wH_w$ $d_wd_wP_wH_wH_w$). If the wind wave is not observed and swell exists, solidi must be entered for the wind wave group. If wind waves exist but there is no swell, it is not necessary to enter solidi for the swell group.

The format of the Ship Code Card (WS Form TA B-0-7) observing aid has been changed. In the new version, the entire weather code with the exception of the ICE group is displayed on one side of the card. On the reverse side appears the ICE group, miscellaneous information, conversion tables, and observing aids. The SHRED code format is also included because of its usefulness when time for a complete observation is not available. It is planned to have this code card translated into several foreign languages to assist non-English speaking marine weather observers.

The Ship's Weather Observations log (NOAA Form 72-1) is also undergoing change in a three-step effort. The cover with observation instructions has been eliminated, and an improved cloud identification chart is planned to replace the cloud pictures now included with each pad of forms. The final step will be a redesign of the log itself. We now favor a booklet-type (9" x 12") log.

A NOAA-NWS Wind Chill Chart (WS Form TA B-0-25) has also been prepared using metric values. It is hoped that this form will aid the mariner in "thinking Metric." Weather Service Observing Handbook No. 1, Marine Surface Observations, is being rewritten, and a correspondence course for marine weather observing is planned.

In all, it is hoped to provide the mariner with instructions and aids to simplify the sometimes complicated job of observing the weather. You can help us by sending ideas on how to improve the forms to:

Marine Program Leader, W521x2
National Weather Service, NOAA
8060 13th Street
Silver Spring, MD 20910

ERRONEOUS ENCODING OF WIND INDICATOR (i_W) IN SHIP REPORTS

The following letter from the World Meteorological Organization was sent to the Permanent Representatives of the members.

ORGANISATION MÉTÉOROLOGIQUE MONDIALE — WORLD METEOROLOGICAL ORGANIZATION

Téléphone : 34 64 00
Télégrammes : METEOMOND GENÈVE

SECRÉTARIAT
GENÈVE - Suisse

Télex:
Case postale N° 5
CH-1211 Genève 20

In reply refer to / Dans la réponse, mentionner
N/ W/SY/CO

GENEVA, 6 June 1977

Annex: 1

Subject : Erroneous encoding of wind indicator (i_w) in SHIP reports

Action required: Implementation of the code table 1855 of Volume I of the Manual on Codes

Dear Sir,

I have been informed by the Permanent Representative of France with WMO that a considerable number of SHIP reports were rejected by the automatic control system due to the erroneous encoding of wind indicator (i_w). Indeed, of 177 reports rejected one automated centre reported that twenty contain an encoding error in which i_w was coded as 2 (9 times), 5 (2 times), 7 (2 times), 8 (2 times), 9 (4 times) and "/" (once). However, according to the existing coding procedures set forth in Volume I of the Manual on Codes (code table 1855), the wind indicator (i_w) shall only be encoded as 0, 1, 3 and 4.

In this connexion, you may wish to inform your shipboard observers of the existing error if your service is participating in the WMO Voluntary Observing Ship's Scheme and to invite their attention to code table 1855 contained in Volume I of the Manual on Codes. This code table is attached as an annex to this letter for your information.

Yours faithfully,

(D.A. Davies)
Secretary-General

Code Table 1855

i_w - wind indicator

Code figure		
0	wind speed estimated	wind speed in metres per second
1	wind speed obtained from anenometer	wind speed in metres per second
3	wind speed estimated	wind speed in knots
4	wind speed obtained from anenometer	wind speed in knots

Tips to the Radio Officer

Thomas H. Reppert
National Weather Service, NOAA
Silver Spring, Md.

CORRECTIONS TO PUBLICATION, WORLDWIDE MARINE WEATHER BROADCASTS, May 1976 Edition

Page 6--Norfolk, VA (NAM): Add freqs. 8090 and 12135.

Halifax, N.S., Canada (CFH): Add time 1330 for ice bulletins.

Page 9--Angmagssalik, Greenland (OZL): Add time 0705; delete freq. 149.6; delete listed freqs. for ice bulletins, insert freq. 420.

Page 13--Rome, Italy (IAR): Delete freq. 4320. Add times and freqs.:

0700, 1900	519	W, F
	4292	
	8530	
	13011	

Page 16--Buenos Aires, Argentina (LPD): Delete time 0130, insert 0118. Delete listed freqs., insert 524, 4262, and 12763. Replace 0148 and 1630 with 0130 and 1615 under footnote 2.

Page 19--Honolulu, HI (NMO): Delete time 2000, insert 2100. Delete freqs. 16455 and 22593, insert 16457.5 and 22472.

Page 26--Mauritius (3BM): Replace footnote 2 with H24; replace footnote 3 with 0600-1400.

Page 34--Fort Collins, CO (WWV): Delete freqs. 20000 and 25000.

Page 35--Comfort Cove, NFld, Canada (VOO): Delete time 0920, insert 0803.

Page 36--Shinnecock, NY (NMY-41): Amend area to read "Watch Hill, RI to Manasquan, NJ." Amend footnote 2 to read "Weather broadcasts only during boating season, May 15 to Oct. 15."

Cape May, NJ (NMK): Delete times 0045 and 1245.

Page 37--Mayport, FL (NMA-10): Delete times 1320 and 1520 add 1410 for 157.1 MHz.

Miami, FL (NCF): Delete times 0000, 0900, 1100, 1300, and 1800; add 1330 for 157.1 MHz.

Page 38--Key West, FL (NOK): Delete time 2000, insert 2200.

St. Petersburg, FL (NOF): Change call sign to NMA-21. Delete times 0420, 1220, 1620, 1920; insert 0320 and 1450 for 157.1 MHz.

Page 39--San Juan, PR (NMR): Delete times 0300 and 1500, insert 0305 and 1505.

Page 46--Fort Collins, CO (WWV): Delete freqs. 20000 and 25000.

Kekaha, HI (WWVH): Delete freq. 20000.

Page 47--Cold Bay, AK (KCI95): Delete times 0535, 0935, 1735, 2135; insert 0500, 0800, 1700, and 2200. Delete freq. 2382, insert 2512 and 4134.9.

Kodiak, AK (WBH-29): Delete times 0230 and 1600, insert 0400 and 1800. Delete freq. 4136.3, insert 4134.9.

Yakutat, AK (KGD91): Delete listed times, insert 0900, 0300, 2100, and 1600.

Ocean Cape, AK (NMJ-19): Add freq. 157.1 MHz.

Juneau, AK (KCI97): Delete listed times, insert 0600 and 1900.

Page 48--Ketchikan, AK (WGG56): Add times 0430 and 1430.

Annette, AK (KGD58): Delete listed times, insert 1000, 2200, 0200, and 1500. Add freq. 4134.9.

Page 49--Port Angeles, WA (NOW): Delete times 0600 and 1800.

Seattle, WA (NMW43): Delete freq. 2670.

Page 57--Stockholm, Sweden (SAY, SMA): Delete time 1020, surface analysis, insert 1013. Delete time 0940, 30-hr surface prognosis, insert 0915. Delete time 1130, 48-hr surface prognosis, insert 1100. Change times for ice chart to 1130 and 1930.

Page 63--San Francisco, CA (WMM55): Delete station.

Pages 77-78--Add the following to list of VHF-FM stations:

Alaska	Homer	WXJ-24	162.40
	Juneau	WXJ-25	162.55
	Ketchikan	WXJ-26	162.55
California	San Luis Obispo	KIH-31	162.55
	Santa Barbara	KIH-34	162.40
Florida	Daytona Beach	KIH-26	162.40
	Key West	KIH-25	162.40
	Tallahassee	KIH-24	162.40
Louisiana	Morgan City	KIH-23	162.475
Michigan	Traverse City	KIH-22	162.475
Oregon	Coos Bay	KIH-32	162.40
	Newport	KIH-33	162.55
Rhode Island	Providence	WXJ-39	162.40
South Carolina	Beaufort	WXJ-23	162.475

Hurricane Alley

Dick DeAngelis
Environmental Data Service, NOAA
Washington, D.C.

Five Southern Hemisphere tropical cyclones reached tropical storm or hurricane intensity during March and April. All of these developed in the Australia-South Pacific region. This is just one-half of the normal total for the Southern Hemisphere for this 2-mo period. The North Indian Ocean was quiet, but this is not unusual as their spring season is just starting.

The tropical cyclone tracks (fig. 44) and intensities are mainly based on information kindly provided by Lee Mace of the National Environmental Satellite Service. The tracks should be considered preliminary.

SOUTHERN HEMISPHERE MARCH AND APRIL

During March a hurricane and a tropical storm roamed the waters off northwestern Australia, while a tropical storm played among the New Hebrides Islands. This is slightly below the average of four storms since Otto in the Gulf of Carpentaria did not make it beyond the tropical depression stage.

Karen and Leo were the systems that hugged the northwestern Australia coast. Karen was detected on the 3d near Ashmore Island, a dependency of Australia consisting of three coral islets enclosed by a reef. On the 4th, Karen reached tropical storm strength. The next day she was generating 50-kn winds near the center which approached Cape Leveque before turning southwestward. Maximum winds climbed to a 60-kn peak on the 6th. Late on the 7th, Karen dipped to cross the coast near Onslow, moved across Vlaming Head, and then back out to sea where she weakened.

Leo came to life in the Joseph Bonaparte Gulf on the 23d. After crossing the swamplands east of Darwin, Leo increased to tropical storm strength on the 24th. He remained off the coast until the 26th, when he turned southward and intensified to hurricane strength. Leo, generating 70-kn winds, moved ashore near Port Headland, a former gold-boom town now an iron-boom town (fig. 45).

Norman, the other March storm, formed among the Santa Cruz Islands on the southeastern end of the Solomons. He headed southwestward but turned a clockwise loop south of 15°S and moved southeastward between New Caledonia and the New Hebrides. Winds reached 50 kn on the 10th and 11th, fell while the

Figure 45.--Leo roars across the coast of northwestern Australia on the 27th.

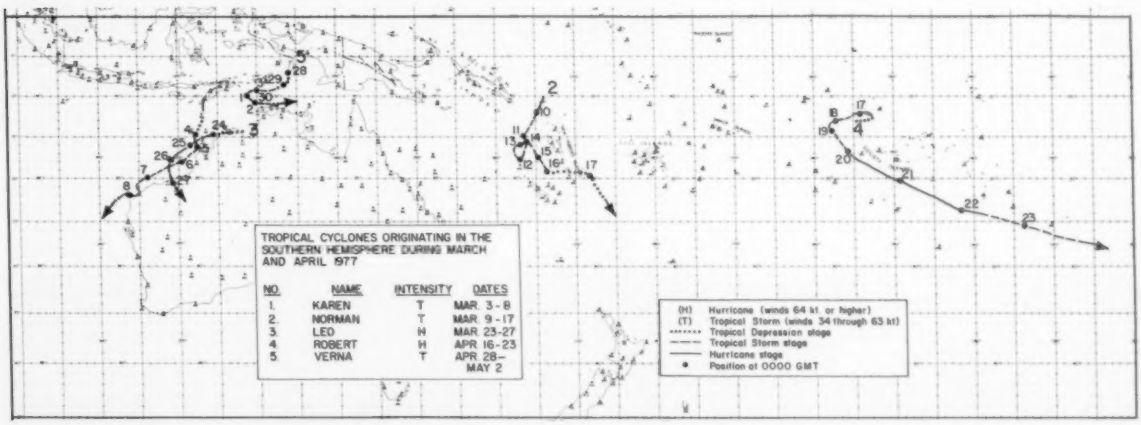

TROPICAL CYCLONES ORIGINATING IN THE SOUTHERN HEMISPHERE DURING MARCH AND APRIL 1977
NO. NAME INTENSITY DATES
1. KAREN T MAR. 3 - 8
2. NORMAN T MAR. 9 - 17
3. LEO H MAR. 23-27
4. ROBERT H APR. 16-23
5. VERNA T APR. 28- MAY 2
(H) Hurricane (winds 64 kt. or higher)
(T) Tropical Storm (winds 34 through 63 kt)
Tropical Depression stage
Tropical Storm stage
Hurricane stage
Position at 0000 GMT

Figure 44.--Track chart for Australia-South Pacific tropical cyclones, March and April 1977.

storm was looping, and then climbed to 40 kn on the 14th and 15th. The following day Norman weakened to depression strength.

April witnessed a long-distance South Pacific hurricane and a short-lived Arafura Sea tropical storm. Robert came to life north of the Society Islands on the 16th. After a few days of indecision, he turned southeastward. On the 20th, Robert achieved hurricane status. Hurricane Robert breezed past the Society Islands on his journey into regions where no tropical cyclone had been tracked before. The increasing latitude was too much in the end, but Robert made it across 130°W and into immortality. Maximum winds were estimated at 70 kn on the 20th and 21st.

Less than 1 week later Verna was spawned in the Arafura Sea. She meandered westward reaching tropical storm strength on the 29th. On the 1st, Verna turned eastward and skimmed the north coast of Arnhemland but petered out on the 2d. Maximum winds were estimated at near-hurricane strength on the 30th and 1st (fig. 46).

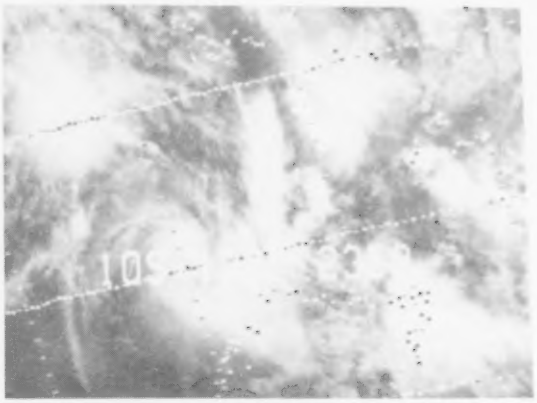


Figure 46.--Verna approaches maximum intensity on the northern coast of Australia very late on the 29th.

On the Editor's Desk

SATELLITE DATA, HAM RADIO OPERATORS HELP CHARTER SHIP

Eighty persons on a round-the-world cruise aboard the 176-ft motor sailor YANKEE TRADER were threatened by a near-hurricane-force tropical storm last April and guided to safety by ham radio operators from two continents with backup from satellite meteorologists.

The YANKEE TRADER, chartered by Windjammer Barefoot Cruises, Ltd., of Miami, was a day out of Pitcairn Island when she encountered a tropical storm 200 mi wide with gusts up to 65 kn.

Seeking weather information to plot a course to safety, the ship put out a call on short wave radio--a call answered by ham radio operators in New Zealand and Chicago. Neither, however, had access to weather information for the South Pacific.

But 5,000 mi away, Donald M. Dibble, a trial attorney and ham radio operator from Mission Hill, Kans., a suburb of Kansas City, overheard the three-way conversation and called NOAA's National Severe Storms Center in Kansas City. The Severe Storms Center passed the call to the Kansas City Satellite Field Services Station (SFSS).

The Kansas City SFSS only had satellite pictures of the Northern Hemisphere, but they contacted Satellite Service offices in San Francisco and Washington, D.C., both of which were watching the storm on satellite imagery. From these, the SFSS was able to provide coordinates for the center of the storm, its direction of travel, and size and recommended a course of travel for the ship to follow to steer clear.

Armed with this information, Dibble went on the air to try to reach the YANKEE TRADER. But the drama was not quite played out. He was unable to raise the ship. Atmospheric conditions do strange things with radio waves, and Dibble found that while he could contact the New Zealand ham, 1,500 mi further west, he could not talk to the ship which, minute by minute, was sailing deeper into peril.

Dibble passed the weather information along to the New Zealand operator whose call to the YANKEE TRADER went unanswered. The Chicago ham radio fan, listening in, offered to try to reach the ship. Again, failure. At this point yet another ham radio operator, in Florida, broke into the conversation between Chicago and New Zealand to report that he was in contact with the YANKEE TRADER.

Thus, the information which originated with a NOAA satellite 22,200 mi (35,720 km) in space went from Kansas City to New Zealand to Chicago to Florida to the South Pacific.

Upon receipt of the weather data and course advisory, the YANKEE TRADER took a new heading and sailed into calmer waters, its passengers shaken but safe.

PROPOSALS INVITED TO DEVELOP OCEANLAB FACILITY

NOAA has requested proposals for a contract to conduct studies leading to development of "Oceanlab," planned to be the world's most advanced mobile underwater laboratory.

Oceanlab will be a national facility for underwater science and engineering, supporting research on living and non-living resources, on the development of offshore energy sources, and obtaining information for marine environmental and resource management. Providing knowledge to help develop and verify safety standards and requirements for undersea operations and diver safety and effectiveness will also be an important part of Oceanlab's mission. The proposed system will include:

-- a mobile undersea facility to operate as a manned engineering and science laboratory, capable of working

at depths to either 300 or 1,000 ft (91.5 or 305 m). The depth capability selected will depend upon relative costs and other trade-offs.

-- a lockout minisub that can extend the research depth to 2,000 ft (609.5 m), with diver lockout to 1,500 ft (457 m). Mission performance requirements, system configuration, and technical specifications and designs developed under the contract will contribute to the development of construction proposals.

The concept for Oceanlab was developed in the Manned Undersea Science and Technology Office of NOAA's Office of Ocean Engineering following extensive consultations with government, academic, and industrial research organizations, commercial firms with underwater expertise, and the recreational diving community.

No new hardware development work will be undertaken as the technology already exists for construction of undersea craft with comparable depth capabilities.

In concept (final design details may vary considerably) Oceanlab will be about 125 ft (38 m) long with a 20-ft (6 m) beam and 450 to 600 tons displacement. In addition to a small crew, it will have a scientific diver capacity of about nine, some of whom can be maintained at one atmosphere (surface pressure). The others can be pressurized to depth for out-of-laboratory research excursions.

Oceanlab's range will be approximately 1,000 mi (1,853 km) on the surface and 50 to 100 mi (92.5 to 185 km) submerged with a 30-day duration. All operations will be independent of surface support.

The companion "lockout-minisub" will be carried piggyback and will operate with the larger vehicle. It is conceived at present as a vehicle of about 35 ft (10.7 m) long with capacity for six persons--two vehicle operators at one atmosphere and up to four divers who can operate from a pressurized compartment. It will have a submerged range of 20 to 30 mi (37 to 55.5 km) and a top speed of about 3 kn.

SATELLITE TRACKS GIANT ICEBERG

A gigantic iceberg nearly the size of Rhode Island is being tracked by satellite during its 2,900-km (1,800 mi) journey along the Antarctic coast toward the open sea east of South America.

The iceberg--one of the largest ever recorded (fig. 47)--appears to be temporarily grounded near the tip of the Palmer Peninsula and later is expected to drift slowly out of Antarctic waters toward South America and into the South Atlantic. There, after being exposed to warmer water, it should slowly disintegrate.

Working closely with NASA's Goddard Space Flight Center, Navy weathermen have been tracking the iceberg since 1971 when it broke off from the Princess Martha coast of Antarctica. They say it is 74 km (45 mi) long, 40 km (25 mi) wide, 230-345 m (750-1,000 ft) thick, and contains enough fresh water to supply Washington, D.C., for 5,000 to 7,000 yr or the state of California for 1,100 yr. Although the idea of towing icebergs for use in arid regions of the Earth has been discussed often in the past, no one has come up with a practical, economical way of doing it.

The iceberg is not expected to be a serious danger to navigation because it is so large. However, if it

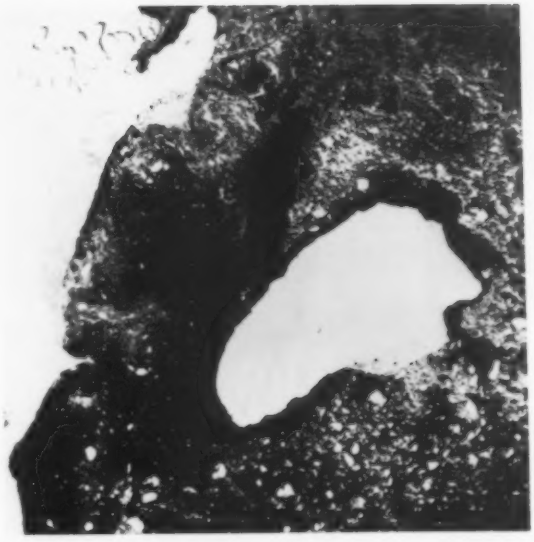


Figure 47.--LANDSAT catches one of the largest icebergs ever recorded, aground on January 31, 1977, near the tip of Antarctica's Palmer Peninsula.

does break into smaller chunks as it moves into open water, they too will have to be monitored closely via satellite by U.S. Navy Fleet Weather Facility (FLEWEAFAC) forecasters in Suitland, Md.

FLEWEAFAC has responsibility for weather forecasting and ice field routings in the polar regions for the Department of Defense and other agencies.

Goddard helps provide satellite analyses during the 6-mo polar night using their microwave radiometer

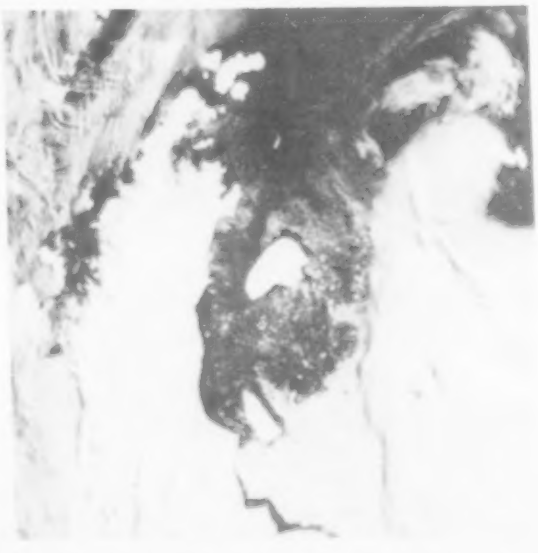


Figure 48.--South of its mother berg and almost as large, the calved berg, looking like the bow of a ship, sits aground near James Ross Island.

on board the Nimbus-5 satellite. It not only can "see" through the dark, but through clouds over the ice caps.

Goddard also routinely supplies LANDSAT (Earth resources satellite) imagery to FLEWEAFAC Suitland for 100 m (300 ft) resolution visual pictures. NOAA weather satellites provide operational visible and infrared imagery on a year-round basis.

Although the "big berg" was first noticed on polar orbiting weather satellite pictures in 1971, research of previous pictures found that it first showed in March 1967. An ice tongue extending out from the Princess Martha coast of Antarctica, still seen on some maps, but actually no longer there, was broken off the ice shelf either by winds or by collision with another large iceberg.

Over the years during its 2,900-km (1,800 mi) journey along the coast, the FLEWEAFAC watched it. In August 1975 it rammed into the Larsen Ice Shelf calving another huge iceberg nearly 22 by 58 km (13 by 36 mi) (fig. 48). This berg is also temporarily grounded near James Ross Island, Antarctica.

Satellite data are used to route shipping through the treacherous polar ice fields. That information is used to designate safe routes to follow for icebreakers or other structurally reinforced ships to make their way through weak ice rather than taking a longer, open water route as was necessary in pre-satellite days. Analysis of satellite data is routinely transmitted to U.S. and foreign shipping with some 14 ships being supported in Antarctica alone so far this winter. For the United States this includes two Navy icebreakers, a tanker, a cargo vessel, and a National Science Foundation scientific vessel. Ships from seven other countries operating in the ice-clogged waters around Antarctica have used FLEWEAFAC services.

CORRECTION TO "FOREIGN AMVER VESSELS CONTRIBUTE TO OBSERVATION PROGRAM"

In the above item from the Editor's Desk section of the May 1977 issue (p. 177), all vessels listed "East Germany" should have been "West Germany." These vessels made a significant contribution to the marine weather observation program. They are the BREMERHAVEN, BLUMENTHAL, ELSFLETH, WESERMUNDE, DELTA GAS, NIENBURG, MINDEN, and VEGESACK.

SHIP LINES RECEIVE SAFETY AWARDS

Marine Transport Lines (MTL) has received two annual Ship Safety Achievement Awards for exceptional actions at sea from the American Institute of Merchant Shipping (AIMS), the first time in the institute's 22-yr history that a single company has received two commendations at the same time.

The first commendation covering actions by U.S. ships in the previous year went to MTL's tanker MARINE CHEMICAL TRANSPORTER in recognition of an action at Ponce, Puerto Rico, when the ship undocked without tugs to escape an explosion in three nearby chemical storage tanks.

"An outstanding teamwork effort by the ship's officers and crew in this critical situation of nearby smoke and flame resulted in safe evacuation with no injuries or damage to the vessel," AIMS said.

The second was awarded to the fully laden SEALIFT CHINA SEA which, while enroute to Sasebo, Japan, displayed excellent seamanship in the nighttime rescue in stormy seas of 31 survivors from the sunken foreign-flag vessel VICTORY GLEE.

In dry cargo, AIMS awarded Puerto Rico Marine Management's FORTALEZA, which saved four members of a sailing yacht in rain squalls, gale-force winds, and high seas. In the inland waterway category, Ohio River Company's towboat QUEEN CITY was honored for saving four persons from an overturned pleasure craft. At the time she was pushing 12 laden coal barges and, on the accident, nine crewmembers rushed to the head of the tow and rescued the foursome before they were swept under the barges. This was accomplished in 10 min in poor visibility.

All of the winning vessels receive National Safety Achievement Pennants, and each crewmember at the time of the event receives a framed citation. Runner-up awards, in the form of Citation of Merit plaques, went to Sun Transport's tanker AMERICAN SUN and Moore-McCormack's freighter MORMACDRACO, both of which in separate incidents rescued survivors from liferafts.

In a joint statement, AIMS president and the general chairman of the Marine Section, National Safety Council, said: "We salute these valiant ships and their courageous officers and crews. Their heroic efforts under stress and adversity are a credit to all men who go down to the sea in ships. The recipients of these awards are living testimonials to the fact that the American merchant marine is comprised of the best manned and safest ocean and inland fleets afloat."

RIP CURRENTS CAN KILL

There is a killer at the seashore called a rip current, but with a little caution swimmers can outwit this dangerous natural hazard.

The rip current is a strong, narrow outflow of ocean water that moves away from the shore carrying back to sea the water brought in by waves. Swimmers caught in rip currents often try to fight their way against them in an effort to return to shore. Such efforts can cause exhaustion, and panic can increase the possibility of drowning.

The rip current can be easily recognized and its dangers avoided, according to Harris B. Stewart, head of NOAA's Atlantic Oceanographic and Meteorological Laboratories in Miami, Fla., who has developed simple rules every swimmer should know before going to the seashore this summer.

Here's how Dr. Stewart describes the appearance of a rip current:

Part of a generally circular pattern of water movement found off most long, gently sloping sand beaches, a rip current can travel at speeds up to 2 or 3 mi/h, often changing position. The same beach may have several of these killer currents at one time and then go weeks without any at all.

Once outside the surf zone, the rip current dies rapidly, spreads out, and often forms a large, sluggish eddy which is called a "rip head."

The rip current breaks up the normal wave pattern running parallel to the beach. One will appear as a crisscross line running perpendicular to the beach. Small choppy waves may form a band from the shore out to the surf zone, and often the rough water will cause a foam line indicating the location of the rip

current. Usually, the surf is lower where a rip current passes through the breakers.

Dr. Stewart's advice to swimmers: stay away from rip currents. If, while swimming, you notice yourself moving faster in one direction along the shore, you should expect rip currents to be developing. If you are walking from the beach into shallow water and feel a current pulling at your legs, you may be able to see a spot down-current where a rip is moving water out to sea. Or look at the end of a jetty, groin, or other solid structure jutting out into the ocean and there will probably be a rip current where the water has been deflected seaward.

You will know when you are in a rip current. Your first indication is that if your feet touch the bottom occasionally, you get the feeling that the bottom is moving fast toward shore. When your feet are no longer touching bottom, you find you are farther out to sea than you had expected, or moving seaward faster than other swimmers near you.

This is the point where most swimmers start swimming their hardest toward shore--a fatal mistake. Since the current is seldom more than 10 to 20 ft wide, swimmers should swim parallel to the beach and will very soon be out of it. An alternative is to relax and let the rip current carry you seaward through the surf zone into the rip head where it slows down. From there, you can have a leisurely swim back to the beach parallel to the rip current.

The basic rules are simple: learn to recognize rip currents and to avoid them. However, if you find yourself caught in one, don't fight it; swim parallel to the beach and at right angles to the current. Or, let the current carry you out until it dissipates, then swim to shore, well away from the narrow rip.

Keep calm and enjoy a safe outing at the beach this summer.

WEST COAST LORAN-C OPERATIONAL

West Coast mariners have had a helping hand to guide them in navigating the waters of the Pacific from the Canadian border to Baja California since April 25, 1977, when the West Coast chain of the LORAN-C radio navigation system became operational. The Gulf of Alaska chain became operational in June.

LORAN (LOng RAnge Navigation) is an electronic system using shore-based radio transmitters and shipboard receivers to allow ships to pinpoint their position at sea. The LORAN-C system will provide 95-percent assurance that a vessel can fix its position to an accuracy of one-fourth mi. It will replace the less accurate LORAN-A system developed during World War II.

The Secretary of Transportation plans to provide LORAN-C coverage for all mariners throughout the U.S. Coastal Confluence Zone and Alaska. The West Coast chain is the first of three Pacific area chains which will cover the Pacific coast from Alaska to Baja by midsummer.

Four newly constructed stations in Fallon, Nev.; George, Wash.; Middletown, Calif.; and Searchlight, Nev., make up the West Coast chain--the first such chain constructed specifically for civilian maritime users. Charts for use with the system are available from NOAA's National Ocean Survey.

Other chains in the LORAN-C system are scheduled to become operational as follows: Canadian West Coast - 1977; Gulf of Mexico (Southeast U.S.) and East Coast reconfiguration (Northeast U.S.) - July 1978; Great Lakes expansion - February 1980.

The decision to implement LORAN-C was based on results of a study of navigation systems by the Coast Guard. Four radio navigation systems were considered--LORAN-A, LORAN-C, differential Omega and Decca. Factors considered in the study included capability to meet the technical requirement and costs including system installation, operating expenses, present investments, and availability and cost of user equipment. Navigational requirements of the various user groups, including merchant mariners, commercial fishermen, and the scientific community were also considered.

TRANSPORTATION ACCIDENTS, 1976

The transportation death toll in the United States leveled off in 1976 after 3 yr of decline, according to preliminary statistics released by the National Transportation Safety Board. There were 49,575 fatalities in all transport modes last year compared to 49,502 in 1975. The difference was 0.15 percent.

Highway fatalities increased by 1 percent from 44,690 in 1975 to 44,807 in 1976. There was nearly a 20-percent decrease in 1974 and a 2-percent decrease in 1975. This is the first upturn in highway deaths, however slight, since nearly 55,000 lives were lost in 1973. Highway fatalities historically account for more than 90 percent of all U.S. transportation fatalities.

In the various modes, grade crossing fatalities increased by 24 percent from 910 to 1,124 and pipeline fatalities by 173 percent from 30 to 82. Other modes all showed decreases: airlines down 64 percent (124 to 45); railroads down 11 percent (564 to 503); marine down 6 percent (1,860 to 1,741); and general aviation down 4 percent (1,324 to 1,273).

The Board's statistics were issued in the form of its annual pie chart of transportation fatalities (fig. 49).

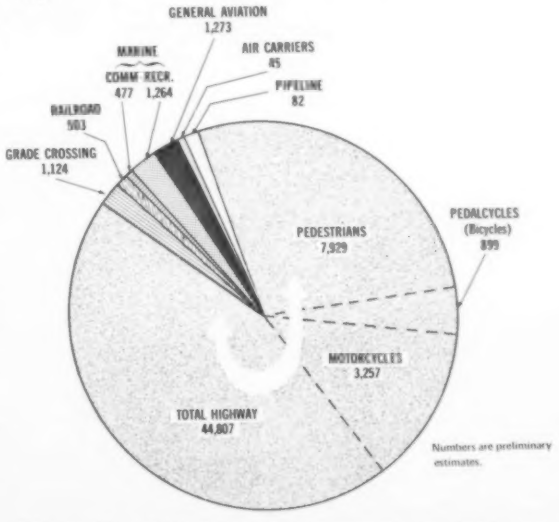


Figure 49.--Distribution of transportation fatalities, 1976.

FIRST JAPANESE WEATHER SATELLITE TO BE LAUNCHED

NASA will launch the Japanese Government's first meteorological satellite into synchronous orbit from Cape Canaveral, Fla., in mid-July 1977.

The Geosynchronous Meteorological Satellite (GMS) weighs 281 kg (620 lb) and represents a major scientific attempt to improve weather prediction over millions of sq mi in the western Pacific Ocean. The GMS program is under the direction of the National Space Development Agency of Japan (NASDA).

From its "meteorological arena" 35,800 km (22,250 mi) in space, GMS will identify, pinpoint, and photograph every major weather pattern from Hawaii to Pakistan. The satellite's cameras will photograph the cloud cover for approximately one third of the world every 30 min, 24 hr a day to help alert meteorologists to potential perilous storms over the Pacific. The satellite will be positioned over the Equator directly south of Tokyo at longitude 140°E.

Mission objectives of the GMS are to observe cataclysmic events such as hurricanes, typhoons, and regional weather phenomena; day and night observation of regional weather; relay meteorological observation data from surface collection points (ships, buoys, and weather stations) to the central processing center in Japan; and to transmit processed imaging data for facsimile reproduction at distribution points in the western Pacific area.

On board GMS is a Visible Infrared Spin Scan Radiometer (VISSR), capable of making highly accurate pictures of the Earth's cloud cover in daylight and in total darkness. The images, which can be transmitted to Earth every 30 min, will enable meteorologists to identify, monitor, and track severe storms, heavy rainfall or cloudbursts, floods, and typhoons.

GMS will also carry a Space Environment Monitor (SEM) to monitor energetic particle activity emanated by the Sun. Extreme solar activity can affect Earth communications. The SEM monitors solar protons, alpha particles, and solar electrons.

The cylindrically-shaped weather satellite is the first of several "weather watchers" to be launched by several countries in an attempt to improve weather prediction for extended periods on a global basis. This international weather satellite program is a major part of the Global Atmospheric Research Project (GARP), which is sponsored by the International Council for Scientific Unions and the World Meteorological Organization. Other countries contributing weather satellites to the GARP Program include the European Space Agency (ESA), the Soviet Union, and the United States. Members of ESA are Belgium, Denmark, France, Italy, Netherlands, Spain, Sweden, Switzerland, West Germany, the United Kingdom, and Ireland.

Under the GARP Program, five geostationary meteorological satellites (two from the United States, one each from Japan, the Soviet Union, and European Space Agency) will be placed in orbit. Additionally, the United States and the Soviet Union plan to launch two satellites each into polar orbit. The mission of these satellites is to:

-- Collect and disseminate observation data on cloud formations and Earth surface temperatures.

-- Collect and disseminate meteorological observations data from ships, buoys, and unmanned observatories.

-- Observe solar protons by space environment monitor.

In addition to those countries participating in the satellite portion of GARP, approximately 145 countries also will make contributions to the worldwide weather effort by taking daily surface and atmospheric measurements in their respective areas.

All of the data will be sent to Central Data Centers in Moscow and Washington, D.C. Current planning calls for the program to be in full operation by December 1978.

COAST GUARD TO INSTALL NEW CODERS

Beginning in September 1977, 69 radiobeacons located throughout the United States will be receiving new solid-state coders. This new equipment, known as GCF-W-782, is designed to provide greater reliability, less cost, and a truer Morse Code signal to the mariner than the old mechanical keyers which have been in use since the end of World War II.

Installation of the new coders is an interim phase of a Coast Guard plan to replace its entire radiobeacon navigation system. The coders were designed to be cost effective so that the equipment would pay for itself over a 5-yr period.

The GCF-W-782 requires fewer person-hours of maintenance than its predecessor, it does not need a separate power source to operate, consumes less energy (less than 1 ampere at 115 VAC; 60 Hz), and has a time drift of less than 4 sec/mo. Thus, the mariner receives better service at a lower cost, and the savings pay for the equipment's use until the entire system is revamped.

Current plans call for the new coders to be installed at initial sites between September and October 1977. The remaining radiobeacons will receive the new equipment within the next year.

NTSB RECOMMENDS COLLISION AVOIDANCE AIDS

The National Transportation Safety Board has recommended that the Maritime Administration develop a plan for the early installation of electronic collision avoidance aids aboard ships using radar to navigate inland waterways. The plan should cover both Collision Avoidance Systems (CAS) and Marine Radar Interrogation Transponders (MRIT).

The Maritime Administration already has taken the lead in requiring the installation of collision-avoidance systems in government-subsidized tank ships, but the Board said there is now no apparent reason to delay further a definite policy regarding the use of these systems.

Both recommendations were a result of the Board's investigation of the collision between the Norwegian bulkcarrier BAUNE and the U.S. tankship KEYTRADER in the lower Mississippi River on January 18, 1974.

The bow of the BAUNE, the inbound ship, penetrated about 20 ft into the two forward cargo tanks on the starboard side of the KEYTRADER. Gasoline spilled from the ruptured tanks, ignited, and burned for 53 hr. Six persons died in the collision. Three others

were injured and 10 persons still are missing.

The Board determined the probable cause of the accident was:

"...the failure of the KEYTRADER pilot to correctly interpret the BAUNE's movements, which led him to make a port turn to position his ship for an improper starboard-to-starboard passing with the BAUNE.

"Contributing to the accident were the operation of both vessels at speeds that did not allow sufficient time to establish a radar trackline compounded by the inadequate use of the shipboard radar to evaluate a safe passing maneuver, the failure to establish communications, and the inadequacy of sound signals under existing environmental conditions."

The Board felt that CAS or MRIT would have significantly increased the probability of the KEYTRADER and the BAUNE detecting each other and would have indicated that the BAUNE was moving upriver and not out of an anchorage area as assumed by the KEYTRADER pilot.

As a result of its investigation, the Board also recommended that the Coast Guard:

-- set guidelines to determine the maximum safe speeds for vessels navigating with radar in limited visibility on inland waters.

-- develop minimum standards for manually processing radar data that will help in evaluating the movements of approaching radar contacts on inland waters.

-- develop and disseminate information about drawbacks in the use of sound signals between vessels, including the effects of environmental conditions on sound.

-- develop guidelines to determine the maximum strength of a current that can allow two-way movement of vessels that are navigating by radar in limited visibility.

HYDROGRAPHIC SURVEY OF LAKE HURON

On June 17, 1977, NOAA and the Canadian Hydrographic Service began a major 5-mo hydrographic survey of Lake Huron, including Saginaw Bay. The survey will provide the latest navigational information of the area.

The hydrographic survey, which includes an investigation of at least seven sunken vessels and other navigational hazards, is part of an extensive program by NOAA's National Ocean Survey to obtain information that will contribute to a new data base for existing charts of Lake Huron, for the construction of new charts, and for support of various ecological, pollution, engineering, fishing, and environmental studies.

The survey covers the northern half of the Michigan side of Lake Huron from Au Sable Point through Thunder Bay to Mackinac to False Detour Channel. It is being conducted by the NOAA ship MT MITCHELL (fig. 50), an 1,800-ton, 231-ft ship newly equipped with $130,000 of the latest U.S. Coast Guard-approved pollution abatement gear that includes a sewage treatment and containment system and oily water separator.

Figure 50.--NOAA ship MT MITCHELL underway during a hydrographic survey.

The MT MITCHELL carries a complement of 77 officers, technicians, and crew. The ship utilizes such devices as electronic control for horizontal positioning of the ship and electronic echo sounder, an instrument that measures water depths by recording the time required for sound waves to reach bottom and echoes to return. As the vessel follows a prescribed course, returning echoes are recorded on a permanent graph at rapid intervals forming a continuous profile of the sea floor.

To provide water-level data to assist in reduction of soundings acquired in the survey, six permanent water-level gage stations operated by National Ocean Survey and located at Detour, Mackinaw City, Harrisville, Essexville, Harbor Beach, and Lakeport will be used. In addition, seven short-term automatic recording water-level gages will be operated at Cheboygan, Presque Isle Harbor, Alpena, Point AuGres, Sebewaing, Port Austin, and Port Sanilac.

The MT MITCHELL will base at the U.S. Coast Guard Station, St. Ignace, Mich., during the survey which is scheduled to terminate next October.

CASUALTIES ABOARD U.S. COMMERCIAL VESSELS

A total of 7,150 ships were involved in 4,211 casualties during the 15-mo period ending September 30, 1976, according to a tabulation contained in a recent issue of the Proceedings of the Marine Safety Council. Storms or adverse weather were the primary cause of 403 casualties, and unusual currents were the primary cause of 10 more. There were 269 deaths and 153 injuries as a result of 186 ship casualties; two of these casualties were the result of collisions in fog, resulting in two deaths and three injuries. Capsizings, founderings, and floodings constitute the category resulting in the highest number of casualties, 72, with 137 deaths and 25 injuries. Of the 186 casualties causing deaths and injuries, storms or adverse weather was the prime cause of only one injury.

In addition to the above deaths and injuries, there were 405 deaths and 1,224 injuries aboard ships not involved in ship casualties. Natural causes accounted for 72 of these deaths, 97 persons fell overboard and drowned, and no deaths were primarily attributed to weather conditions. Three injuries were a direct re-

sult of weather.

Casualties involving commercial vessels are required to be reported to the U.S. Coast Guard whenever the casualty results in 1) actual physical damage to property in excess of $1,500, 2) material damage affecting the seaworthiness or efficiency of a vessel, 3) stranding or grounding, 4) loss of life, and 5) injury causing any person to remain incapacitated for a period in excess of 72 hr, except injury to harbor workers not resulting in death and not resulting from vessel casualty or vessel equipment casualty.

NOAA GRANT ESTABLISHES REGIONAL INFORMATION CENTER IN RHODE ISLAND

A network of coastal information centers for planners, marine resource managers, scientists, and the public will soon get its start with the establishment of the New England Regional Coastal Information Center at the University of Rhode Island's Pell Library on Narragansett Bay.

Funds for the new service, a $50,000 grant, come from NOAA's Office of Sea Grant, Office of Coastal Zone Management, and the Environmental Data Service. An additional $25,000 has been pledged by the University of Rhode Island. The regional centers will be administered through local Sea Grant programs.

The New England center will be a prototype for a system of highly specialized facilities in as many as eight other locations on the Great Lakes and along the Atlantic, Pacific, and Gulf coasts. The center will allow members of state agencies, coastal planners, legislators, environmentalists, and the general public to obtain information and guidance on coastal area subjects, including laws and zoning regulations, scientific data, and sources of publications.

In addition to providing information on coastal zone activities to a number of different groups in New England, this first regional center will also act as a referral service, exchanging information and publications among state and local governmental agencies, citizen groups, special interest groups, and the general public on the wide-ranging subjects of coastal resource planning and management.

MARINE WEATHER REVIEW

The SMOOTH LOG (complete with cyclone tracks [figs. 58-61], climatological data from U.S. Ocean Station and Buoys [tables 6 and 7], and gale and wave tables 8 and 9), is a definitive report on average monthly weather systems, the primary storms which affected marine areas, and late-reported ship casualties for 2 mo. The ROUGH LOG is a preliminary account of the weather for 2 more recent months, prepared as soon as the necessary meteorological analyses and other data become available. For both the SMOOTH and ROUGH LOGS, storms are discussed during the month in which they first developed. Unless stated otherwise, all winds are sustained winds and not wind gusts.

Smooth Log, North Atlantic Weather

January and February 1977

SMOOTH LOG, JANUARY 1977--Storm activity was near normal this month. The tracks over the water were generally south and east of the climatological tracks. There was a clear-cut concentration of storm-center paths over the Great Lakes, but most of these curved northward over Quebec and Labrador and did not significantly affect the open sea. The cyclones out of the eastern United States generally had a more easterly component than the climatic normal, with about half curving northward to buffet Newfoundland and the other half continuing eastward and then turning northward south of Iceland. An inverted high-pressure ridge over Greenland protected the sea around and north of Iceland. During the second and fourth weeks of the month, several storms moved across Europe, preferring the English Channel. The last week three storms affected the Mediterranean Sea. One storm moved northward across the Azores from the vicinity of 21°N, 40°W.

The mean low-pressure centers at 1000 mb and 1005 mb were within 1 mb of the climatic normal pressure but were greatly shifted southeastward from their normal position. A 1001-mb center normally near 60°N, 35°W, was 1000 mb near Belle Isle. The 1005-mb secondary Low normally off the central coast of Norway was 1005 mb between Iceland and Ireland. The Azores High was 1023 mb along latitude 30°N south of the Azores. The pressure over the eastern third of the United States was less than normal.

The most intense pressure anomaly was a positive 15-mb center between Greenland and Iceland near 63°N, 35°W. A large negative anomaly had three 9-mb centers--near James Bay, the Gulf of St. Lawrence, and near 40°N, 60°W. A negative 5-mb center was over the English Channel.

The upper-air circulation at 700 mb had the same general configuration as climatology, but it was shifted slightly to the south and east over the eastern Northern

Hemisphere. The primary Low center was near 53°N, 70°W, rather than northern Baffin Island. The trough line basically paralleled the U.S. East Coast instead of west of the Appalachian Mountains. The slight ridge that normally exists over western Europe was shifted westward and replaced by a shallow trough. A very sharp ridge replaced the slight ridge that normally occurs over the West Coast from California to Alaska. This resulted in much colder air from northern Canada being advected over the eastern United States. The primary anomaly centers were positive over the U.S. West Coast and negative over New England and northwestern Europe.

Extratropical Cyclones--The first severe LOW of the new year originated over the Gulf of Mexico on the 2d. It moved along the Gulf Coast, over northern Florida, and on the 4th was over the Gulf Stream off Cape Hatteras. The EXXON HUNTINGTON was off Charleston, S.C., and measured 42-kn northerly winds with 10-ft seas. At 1200 on the 5th, the LOW was 994 mb near 40°N, 60°W. At 1800 the EXPORT AMBASSADOR (37.4°N, 54.3°W) found 45-kn gales with 20-ft swells out of the south. On the 6th at 0000, the 980-mb LOW was 100 mi south of Argentia. Near 42.5°N, 54°W, the CHASTINE MAERSK was 210 mi southeast of the center with 40-kn southwesterly winds; the seas were climbing 38 ft up her bow, while the swells from 160° were slamming 30 ft against her portside. The SHAFTAFEU was just outside St. Marys Bay with 45-kn winds.

The storm continued on a northerly course, and by 0000 on the 7th it was west of Kap Farvel. It slowly moved up the west coast of Greenland and broke upon the rocky shore and cold ice.

On the 7th, a warm front extended across central Florida to just off Cape Hatteras. At 1200 a wave formed on the front near Hatteras. It developed extremely rapidly. In 12 hr the pressure dropped from 996 mb to 970 mb off Cape Cod. At 1800 the ARECIBO and STRATHAIRD were both in the vicinity of 33.5°N, 71°W, with 60- and 50-kn winds, respectively. The EXPORT AMBASSADOR was now at 39.3°N, 69.9°W, with 70-kn hurricane-force winds. At 0000 on the 8th, the SEVERNYY VETER (40.5°N, 71.7°W) and the CG11 (43.4°N, 65.6°W) experienced 60-kn winds from opposite directions as they straddled the LOW. At 0600 OWS Hotel fought 50-kn winds and 26-ft seas. The TRINITY near 40°N, 68°W, was hammered by 30-ft swells.

Forty and 50-kn winds continued, and at 0000 on the 9th, the LOW was near 41°N, 55°W, at 977 mb. The LUTZ JACOB was at 35.5°N, 58.9°W, with 64-kn northwesterly winds. The swells were 30 ft. Later in the day, the storm started to weaken; by 0000 on the 10th, it was only a trough behind the front.

The empty tanker CHESTER A. POLING broke up about 6 mi off Cape Ann on the 10th. The winds were reported as 60 kn and the waves 35 ft. Six crewmen were saved by the Coast Guard cutter CAPE GEORGE and by helicopter. One crewman was lost.

A LOW which began over Louisiana moved northeastward on the 9th. On the 10th a frontal wave formed southeast of the original LOW as it moved northward over Ohio. At 1200 on the 10th, the wave was only 995 mb, but it was still associated with the overall circulation of the parent LOW. As the storm center was over Cape Charles, the OVERSEAS NATALIE (36.5°N, 71.6°W) had 50-kn southerly winds and 23-ft seas and swells. At 1800 OWS Hotel reported 52-kn storm winds and 26-ft seas, which continued into the 11th. Both the GYPSUM EMPRESS and VGBZ were in the eastern part of the storm with 60-kn winds. At 1200 the THUREDRECHT (40.7°N, 59.8°W) was helped along by 63-kn winds on her stern. Waves of 23 ft were rocking her. On the 12th the 986-mb LOW was headed into northern Quebec. Gale-force winds were still blowing south and east of the Maritime Provinces. At 1200 the GWENOLA, well south of the center at 41.3°N, 65.9°W, radioed 72-kn winds from the west. The Norwegian TEMERAIRE sustained a crack in its portside 180 mi southwest of New York. The seas in the area were reported as 24 ft with 40-kn winds. On the 13th the LOW was over Hudson Bay and headed northwestward.

A large, deep LOW moved into the Barents Sea the first week of the month and remained quasi-stationary off Norway's northern coast. On the 9th another LOW from the west moved over the North Sea, drawing the Barents Sea LOW southward. This large, multicentered LOW dominated the weather over northern Europe for many days. On the 12th one of several centers was analyzed over Ireland's northwest coast. By the 13th it was the larger of the cyclonic circulations and was moving southward. At 0000 OWS Romeo measured 40-kn winds with 16-ft seas. The DOCTOR LYKES measured 60-kn winds with 25-ft seas and 33-ft swells at 1800 south of Plymouth, England. Earlier, ships had found 20-ft waves south of Ireland.

On the 14th at 1200, the LOW was 972 mb north of London. The weather station at Brest, France, measured winds of over 40 kn. The DOCTOR LYKES was now near Bishop Rock with 50-kn winds, 13-ft seas, and 16-ft swells. On the 15th, the ECUADORIAN REEFER southwest of Fastnet Rock found 16-ft seas and swells. The LOW was drifting toward Denmark as it weakened, and a small high-pressure center moved toward the Bay of Biscay. On the 16th the LOW broke into several centers.

A small closed circulation was revealed by a report from an unidentified ship in an area of weak gradient near 37°N, 62°W, on the 0000 chart of the 13th. It developed very rapidly and was 990 mb by 1200 and about 900 mi in diameter. The KURRYSHEVGES was about 360 mi southwest of the center with 45-kn winds and 36-ft seas. Forty- to 50-kn winds were reported several times.

At 1200 on the 14th, the storm's central pressure had plunged to 974 mb near 48°N, 48°W. The HUMERGATE, near 41.4°N, 53.5°W, had 50-kn winds, 28-ft seas from the northwest, and 39-ft swells from the north on her westerly track. About 600 mi directly south of the center the OROTAVA BRIDGE was running with 43-ft swells on her stern. Swell of over 25-ft was not uncommon. At 1800 a ship west of Kap Farvel was blasted by 64-kn winds. Two other ships about 300 mi south and west of the center had winds in the 50-kn category. The MANCHESTER CHALLENGE (46.4°N, 46.6°W) suffered 50-kn winds and 30-ft waves. On the 15th, OWS Charlie fought 56-kn winds and 20-ft

seas. As the storm moved north of the east coast of Newfoundland, it weakened and died on the 17th.

The storm-breeding ground off the Carolina Capes also spawned this monster on the 15th. As usual, it developed rapidly as the cold air moved over the warm Gulf Stream. By 1200 the 988-mb LOW was at 39°N, 68°W. The TROLL PARK was at 35.6°N, 65.7°W, with 60-kn southwesterly winds and 20-ft waves. A ship reported 50-kn winds and 33-ft swells very near the center.

This storm was moving eastward instead of north to northeastward as the previous one did. Under the zonal flow, it was racing along--a small, but potent storm. At 1200 on the 16th, the 980-mb center was near 43°N, 43°W. The main area of the storm was no more than 400 mi in diameter. Two ships were caught near the center. The JORDAENS had her bow into 60-kn winds and 26-ft waves in the southeast quadrant. In the southwest quadrant, the ZAWIERCIE was sailing into 50 kn with no seas reported.

On the 17th the storm turned northeastward. The buoy at 61.7°N, 29°W, reported 52 kn at 0600, and a ship off Brest reported 55 kn with 33-ft swells at 1200. At 1200 on the 18th, the storm was still small in area, but it had a strong gradient (fig. 51). South of the storm the LEO SCHROEDER (51.9°N, 23.5°W) had 60-kn westerly winds and 33-ft seas. Other ships were finding 40- to 50-kn winds and waves around 25 ft. The storm was weakening on the 19th, but another small LOW raced in from the west and reinforced it on the 20th. The DLHO reported 50-kn winds and 26-ft waves as she headed westward. On the 21st the UUDH had 60-kn southerly winds south of Lands End. The LOW moved northward toward Iceland and dissipated by the 23d.

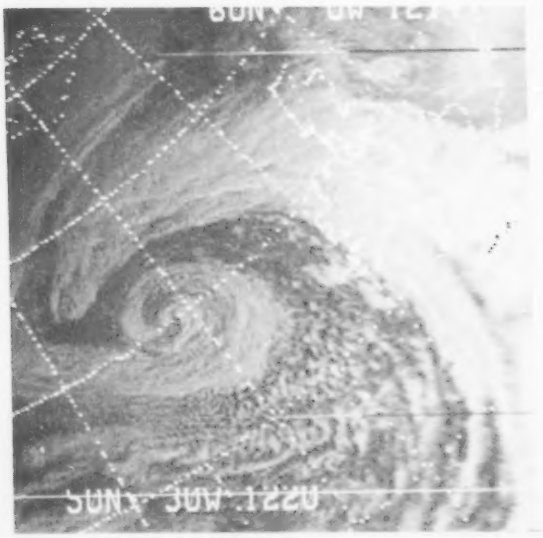


Figure 51.--A sharp front east of the LOW is crossing Ireland. The strong gradient of the LOW is reflected by the tight curvature of the clouds near the center.

Monster of the Month--This storm developed off the U.S. East Coast on the morning of the 19th as a cold HIGH pushed southward over the Midwest. The instability over the Gulf Stream gave the TAMPA 55-kn winds with 20-ft waves and the TRANSPANAMA 50-kn winds with 30-ft waves off the Florida coast at 1200. At 1800 the TAMPA had 60-kn winds and 41-ft waves at 26.3°N, 74.3°W. The ARECIBO (29.9°N, 70.7°W) also suffered 60-kn winds but only 15-ft waves.

By 1200 on the 20th, the central pressure had plummeted to 956 mb near 46°N, 53°W. The strongest reported winds were well south of the center near 35°N. The DOCTOR LYKES (34.8°N, 53.9°W) had 75-kn winds, and the THORSTREAM (34.5°N, 55.2°W) suffered 64 kn. The storm was moving northward just off the east coast of Newfoundland on the 20th. Mr. Gates of the Canadian Atmospheric Environment Service reported that record low sea-level pressures were recorded at several stations of which the most notable was St. Anthony (51.5°N, 55.8°W) with 940.2 mb. He reports that this was the lowest sea-level pressure ever reported in Canada and, possibly, North America. Many ships reported winds in the 50- to 60-kn category. The highest was 60 kn from the south by the SKIENSFJORD at 48.5°N, 48.5°W, with 38-ft seas and a pressure of 962 mb.

The high winds and seas continued on the 21st, 22d, and 23d as the storm turned eastward. Some of the higher sea or swell reports were: C.P. TRADER, 62 ft; ELBE EXPRESS, 33 ft; EXPORT BUILDER, 49 ft; EXPORT DIPLOMAT, 36 ft; SKIENSFJORD, 46 ft; and DLHO, 49 ft.

On the 23d another LOW which had developed off Nova Scotia raced south of the original storm with some weakening of the winds and seas. This was followed by a second LOW on the 24th. By the 25th both of the secondary systems had been absorbed into the original circulation, and the storm was again producing high winds. The UKGS was blasted by 68-kn winds at 48°N, 41.6°W, and OWS Romeo fought 62-kn winds and 23-ft seas. A ship near 50°N, 31°W, was sailing into 41-ft swells. Winds near 50 kn were common.

Late on the 25th, the LOW began to break up into multiple centers. At 1200 on the 26th, the REVERE, south of one of the subcenters, reported 80-kn winds, and a ship to the northwest was swept by 31-ft seas. On the 27th high winds were reported in the English Channel. On the 28th the LOW rapidly weakened as it circled to the south; it disappeared on the 29th.

There is always one that is different. This storm developed off Delaware Bay and spent only a short time over the water. It circled northwestward to Hudson Bay where it turned southward.

It formed as a wave on a front early on the 25th. On the 26th it moved over the Bay of Fundy still developing. At 1200 it was 980 mb south of the Gaspe Peninsula, and its deep trough extended south to 20°N. The ANCO EMPRESS at 40.4°N, 59.8°W, was tossed by 60-kn winds and 39-ft seas and swells. At 1800 the SEA-LAND MARKET (42°N, 57.6°W) reported 45-kn winds but the swells were a monstrous 49 ft. At 0600 on the 27th, a ship appearing to be the NVYA reported 76-kn northerly winds off Cape Charles.

By the 28th the 966-mb storm was centered over northern Quebec and the CG11 near Cape Sable was blasted by 80-kn winds. Late that day, another LOW over southern Quebec cut the circulation off from the sea.

Shipping was hampered on the bays and rivers along the northeast coast of the United States during the last half of the month. Rivers of the Midwest were frozen solid, with shipping halted or delayed north of the Mississippi-Ohio River junction.

Casualties--The 3,312-ton ANGEL sank in a storm 70 mi off Menorca. Seven of the crew of 18 were reported saved. Two separate ship collisions in heavy fog on the Sea of Marmara sank two freighters with 2 seamen dead and 28 missing. The ADMIRAL ZMAJEVIC (8,569 tons) and the TURNU SEVERIN (1,720 tons) collided and the later sank. The IVAN SECHENOV (5,626 tons) and 7,324-ton NICOLAS MARIS also collided.

The Panamanian LIZA sank in heavy weather about 350 mi east of Tampico, Mexico, on the 11th. She was in tow by the tug RUMPOINT. The tank barge B.F.T. No. 50 struck an icefloe in the Hudson River on the 11th and sustained a large crack spilling 15,000 gallons of cargo. The 1,041-ton Cypriot SIGRID broke anchor during strong winds on the 15th at Rijeka, Yugoslavia, struck a breakwater, and sank. The crew was rescued. The UKOLA broke in two and sank on the 19th while about 200 mi west-northwest of Key West. The vessel apparently encountered heavy weather and began taking water in the holds. Of the 23 crewmen 3 were saved, 7 killed, and 13 missing. Two Coast Guard aircraft, a helicopter, the cutter COURAGEOUS, and seven merchant ships participated in the search and rescue. The three survivors were picked up by the MARINE TEXAN, ENIGHEDEN, and the helicopter. The other vessels were the ARIZONA, EAGLE TRANSPORTER, EXXON HOUSTON, EXXON WASHINGTON, PENNSYLVANIA SUN, and VALLEY FORGE. The cruise ship FANTONE, a four-masted schooner, ran aground when she lost power while 23 mi from Nassau on the 19th. Owing to heavy seas and high winds, the 110 passengers were evacuated by the U.S. Navy vessel PETROL and the U.S. Coast Guard cutter STEADFAST.

The American FORTALEZA, New Jersey to San Juan, encountered heavy weather on the 21st near the Bahama Islands. The vessel was carrying cargo in containers and 29 were lost overboard and another 20 damaged. The Coast Guard reported 60-kn winds and waves of 50 ft in the area. The Canadian AIME GAUDREAU was drifting in ice in a northwesterly direction on the 26th near St. John, Brunswick. Another tank barge, the B. No. 65, grounded at the entrance to Cape Cod Canal because of ice on the 28th. The bottom was torn open leaking cargo.

SMOOTH LOG, FEBRUARY 1977--There were two primary storm tracks over North America this month, and they converged into one south of Newfoundland. This combined track traced a path eastward to near 35°W and turned northeastward toward Iceland, where the storms generally dissipated or curved back westward. Only one significant storm penetrated into the Norwegian Sea and that originated off Ireland. Two storms made the long voyage from the east coast of the United States all the way to Europe. Normally, there are tracks into the Davis Strait and Denmark Strait. These were missing this month, except for isolated short-lived LOWs.

The sea-level pressure and pressure-level height means at least partially explain their behavior. The primary Icelandic Low was deeper than normal this month, and it was located southeast of its climatic position--992 mb near 55°N, 30°W. A secondary LOW east of Nordkapp, Norway, was only a trough in the mean picture. The Azores High was 6 mb higher than normal, but it was normally located near 29°N, 30°W.

In the upper-air picture at 700 mb a LOW was 10° longitude west of its surface counterpart. This was an anomalous Low, as the primary one was far north over the Queen Elizabeth Islands. There was also an anomalous High at 70°N off the east coast of Greenland and north of Iceland.

These differences from climatology resulted in some large anomalies. At both the surface and upper air, there were large negative anomaly centers in the vicinity of 50°N, 20°W. The area over the Norwegian, Greenland, and Barents Seas was dominated by positive anomaly values.

Extratropical Cyclones--On February 1 there were several small cyclones across the shipping lanes, but none were strong. For a winter month the area of flat gradient over Nova Scotia and Newfoundland was large. This could not exist for long; and by 1200 on the 2d, a LOW had formed over Cape Race. Gale-force winds began blowing almost immediately. A ship south of Cape Race had 25-ft swells, and the SAM RATULANGIE (37.5°N, 45.6°W) measured 44-kn winds and 33-ft seas. The seas increased to 36 ft on the 3d and were back to 33 ft on the 4th and 5th as the ship sailed westward.

At 1200 on the 3d, the 970-mb LOW was near 46°N, 40°W. The FNGK was at 34°N, 31.5°W, with 80-kn winds and 25-ft waves. Other ships with 50- to 60-kn winds were the MUENCHEN, T. AKASAKA, and KCMH, with the later reporting 33-ft waves. Twelve hours later on the 4th, the OGDEN WABASH battled 83-kn winds off the U.S. East Coast. Closer to the 958-mb LOW, the STEPHANITOR was sailing into 60-kn winds and 33-ft seas about 550 mi south of the center, while the ELBE EXPRESS was only about 60 mi from the center with 60-kn winds and 30-ft seas. At 0600 she reported only 52-kn winds, but the same seas. From 0600 to 1800 the TILLIE LYKES was sailing westward about 120 mi south of the center.

She suffered 65- and 75-kn winds with 30-ft seas for those three observations as she moved into the southwest quadrant. A note attached to her observation form indicated the barometer bottomed out at 957.3 mb at 0200 at 49.3°N, 36.2°W. Winds were gusting to 105 kn with squalls. The seas were mountainous and confused with horizontal spray with the seas often obscured from the bridge. At the same time many other ships farther from the center were reporting winds in the 40- to 60-kn range and up to 25-ft waves.

The central pressure was on the rise by the 5th, and transient LOWs were further weakening the storm. The AMERICAN LEGACY was near 51°N, 33°W, with 15-ft seas and 31-ft swells. The MANCHESTER COURAGE had 45-kn winds not far from the center, at 48.2°N, 31.4°W, with battering 25-ft seas and 38-ft swells. Later that day they just disappeared.

This storm formed near Wheeling, W. Va., on the 5th. The AMERICAN RANGER was about 300 mi south of the center as the LOW moved eastward with 56-kn winds. OWS Hotel measured 48-kn winds after frontal passage. By 1200 on the 6th, the storm had a 962-mb center at 44°N, 59°W. The EL TAINO was about 400 mi south of the center at 36.8°N, 60.7°W, when struck by 60-kn westerly winds and monstrous 57-ft seas. Gales were blowing elsewhere driving seas up to 25 ft. At 1200 on the 7th, the ROMAN PAZINSKI (44.4°N, 47.6°W) had balmy 48-kn winds, and 36-ft swells were pounding her port side.

The 1200 chart of the 8th showed the large 954-mb storm spanning the North Atlantic from shore to shore. The SEALAND MARKET near midocean (34°N, 40°W) had winds in the 40-kn range with swells of 33 ft and 39 ft on the 8th and 9th. The ASIA FREIGHTER was in the wrong seas with 60-kn southwesterlies at 46.4°N, 31.8°W. The swells were rolling by at 57 ft. On the 9th the high winds and seas continued. The POST CHARGER was hammered by 41-ft swells. In the approximate area of 42° to 47°N and 32° to 38°W, five ships found winds of about 50 kn. The POST CHARGER now had 46-ft swells, and the ASIA FREIGHTER had 49-ft swells. At 1800 two more ships in the area found high winds and waves--the ANONA, 64 kn and 46 ft; and the TAUPO, 50 kn and 56 ft.

At this time the center was weakening and tracking eastward along 55°N. Winds and seas were decreasing as the storm split into multiple LOWs. There were still winds in the 40-kn and seas in the 20-ft category. On the 12th the AMERICAN ARCHER was pounded by 25-ft seas and 33-ft swells west of Lands End. On the 13th, the storm dissipated off Ireland.

This was a fast developing frontal wave that first appeared on the 1800 chart of the 16th off Cape Hatteras. The storm moved northeastward. On the 17th at 1800, the DIETRICH OLDENDORF, near 38°N, 56°W, was tracking into 60-kn winds and 33-ft swells. At 0000 on the 19th, the whirlpool of a storm was 956 mb centered near 49°N, 40°W. The NORD was about 200 mi east of the center with 60-kn winds from the southeast. The Canadian ship VGLV was even closer to the center with 47-kn winds and 25-ft seas. At 1200 a ship had 55-kn winds with 49-ft seas and swells near 42°N, 33°W. The S. KATHARINEN, 500 mi southwest of the center, battled 60-kn westerly winds and 26-ft waves. Waves in the 20- to 25-ft class were south of the LOW.

One cyclonic circulation again dominated the North Atlantic shipping lanes. As the storm crossed the 20th meridian at 53°N on the 20th, the MAYA was crossing the 19th meridian near 43°N with 90-kn winds on her starboard bow. OWS Romeo measured 31-ft seas.

At 1800 the C. P. DISCOVERER was headed westward directly into 55-kn winds and 46-ft seas. The TRIDENT ROTTERDAM not far away had 45-kn winds and 33-ft seas. OWS Romeo was fighting to stay on station with 45-kn winds and 43-ft seas. The storm was traveling slowly as it approached the English Channel and stalled for clearance for 24 hr below Ireland on the 22d and 23d. The DISCOVERER still had 43-ft swells on the 21st. Winds of 40 to 50 kn and seas up to 30 ft were still being reported south and west of the center.

On the 23d the storm was wearing itself out with friction over the land, but it still managed to cross into the North Sea.

A large, deep, cold LOW moved up the east coast of the United States and was off Labrador on the 22d. A cold HIGH was over central Canada, and this LOW formed over western Quebec in the col area south of and between the pressure centers. As the first LOW moved northward over the Labrador Sea, the new one moved eastward. The first gale-force winds were reported by St. Pierre Island on the 24th. By 1200 the storm was over warmer, more friendly waters near 52°N, 42°W, at 974 mb. The storm passed over the AMERICAN CHALLENGER, and she suffered 50-kn thunderstorm winds with 16-ft seas and swells. Ocean Weather Station Charlie, east of the center, had 45-kn winds and 16-ft seas. The MANCHESTER CRUSADER, 360 mi southwest of the storm's center, was sailing into 33-ft seas and 36-ft swells. At 1800 the C. P. DISCOVERER was pounded by 39-ft swells. Winds of strong gale and storm force were found in the southern half of the storm.

The 1200 chart of the 25th showed the LOW split into three centers. The DART AMERICA had 50-kn winds and 23-ft seas on her bow. Another British ship had 33-ft swells east of the center. At 0000 on the 26th, the DART AMERICA (44°N, 43°W) still had 50-kn winds, but the swells were 39 ft. The ORDUNA was more south of the center and had 41-ft swells. Two ships reported 60-kn winds at 1800. On the 26th the storm was weakening, and the high waves had rotated to the eastern quadrant of the storm. On the 27th a new LOW moved in from the southwest, and one of the transient LOWs became the main center.

This storm formed near 40°N, 56°W, on the 26th at the occlusion of a frontal system that stretched eastward from a LOW off Maine. The ORDUNA was headed toward the East Coast with 50-kn winds, 39-ft seas, and 33-ft swells. By the 27th the storm was expanding its area of influence, and at 1200 it was 978 mb at 41°N, 37°W. Gales with waves to 25 ft were being reported, with the TOYOTA MARU battling 33 ft near 36°N, 51°W. At 0000 on the 28th, the few winds reported were not high, but the swells were 33 and 36 ft about 900 mi out in the southwest quadrant.

On March 1 the LOW turned northward toward Iceland, and another LOW formed in the trough 1,000 mi to the south. The CUNARD CHAMPION was off

Fastnet Rock with 25-ft swells. The NORTHERN was about 200 mi north of the center on the 2d with 50-kn easterly winds and 26-ft seas. On the 3d the LOW turned westward to stall and fill.

Casualties--The 15,914-ton tanker FIONA JANE became icebound on the 3d in the Gulf of St. Lawrence and sustained a 2-ft fracture of the port side shell plating. The American barge ETHEL H., loaded with 60,000 barrels of heating oil, struck a submerged object in the Hudson River on the 4th. The barge ran aground and, partially submerged, leaked oil into the river. Cleanup was hampered by heavy ice on the river.

The AMERICAN ARCHER (15,864 tons) was at Hamburg on the 8th with heavy weather damage. The 48,320-ton tanker OSWEGO GUARDIAN was surveyed afloat in the Delaware River during the first week of the month for heavy weather damage that occurred in January. The ISLA DE SAINT PIERRE broke tow in heavy weather and sank off Fastnet Rock on the 8th.

Early in the month a 6,592-ton Greek freighter parted its towline in bad weather near Brindisi and went aground. About midmonth the 22,189-ton VOLNAY was at Houston for survey and repair of heavy weather damage.

An engineer was killed and 29 crewmembers abandoned the burning 2,350-ton East German freighter INSELBERG after a collision with the 3,200-ton Finnish cargo ship BORE 11 in thick fog northwest of Bornholm.

Smooth Log, North Pacific Weather

January and February 1977

SMOOTH LOG, JANUARY 1977--The area south of the eastern Bering Sea was congested with storm tracks. The area was bounded roughly by 35°N, 150°W, and 60°N, 180°. The storms had a more easterly component than the normal climatology until the center passed 180° where they curved sharply northward to dissipate between 55° and 60°N. There also were many storms which developed in the southern part of this congested area and traveled northward. Only three low centers penetrated the west coast of North America. Alaska was also slighted, as only one significant center moved farther north than 60°N, and that was along its west coast through the Bering Strait.

Orientation and placement of the tracks of the storm centers were reflected in the mean pressure pattern for the month. The Aleutian Low was 983 mb and centered near 48°N, 170°W, about 20° longitude east of its normal 999-mb location. The high-pressure center off the California coast was in accordance with the normal, but the center normally over the northwestern States was centered farther north and 5 mb higher than normal at 1026 mb.

The 22-mb negative anomaly associated with the Aleutian Low dominated the Pacific north of 25°N. It was centered near 48°N, 170°W. An 8-mb positive anomaly dominated the Pacific Northwest coast from Alaska to northern California.

As with the surface, the upper-air circulation center was many miles east of its climatic position. The central height at 700 mb was 86 m lower than normal, but the shift of its center from over the Sea of Okhotsk to 50°N, 180°, was probably more significant. A large negative anomaly, centered near 46°N, 172°W, covered most of the ocean north of 25°N, except for a positive area centered near the Queen Charlotte Islands. This was associated with a sharp ridge over the West Coast. This sharp ridge and the lack of storm centers off Alaska and British Columbia are closely associated.

Extratropical Cyclones--The first storm of the month had its infancy in December but matured in January. At 0000 on the first day of the year, a 986-mb center was near 39°N, 176°E. The PACIFIC BEAR southeast of the storm measured winds of only 42 kn, but the seas were 20 ft and the swells 30 ft. By 1200 the pressure had dropped to 966 mb, centered near 45°N, 177°W. The MONTIRON was at 43.2°N, 173°W, with 55-kn southwesterly winds. The OREL had bitter, cold 50-kn winds while fishing near 60°N. The center was on a northerly track. A ship southwest of the center had 40-kn winds and 18-ft seas on the 2d. At 0000 on the 3d, three other Soviet ships in the vicinity of 60°N, 180°, had 45- to 60-kn winds. Saint Paul Island reported roaring 80-kn winds from the south-southeast. On the 4th the LOW was integrated into the larger circulation.

This was a short-lived LOW. It formed on the 2d from an elongated double LOW that paralleled the British Columbia coast on the 1st. At 1200 on the 2d, it was 990 mb near 48°N, 132°W, off Vancouver Island. The buoy EB21 near 46°N, 132°W, reported 40-kn winds and 23-ft seas. At 1800 the ARCO JUNEAU was near 46°N, 130°W, and logged 50-kn winds with 25-ft seas and 49-ft swells. The LOW moved south along the coast on the 3d, producing 35-kn winds and 23-ft seas at EB16. A ship west of the center had 16-ft waves. That afternoon the LOW moved inland near Cape Blanco and dissipated in the mountains.

This storm was part of the larger circulation. It formed in a trough on the 2d near 38°N, 167°E. Gale-force winds and 20-ft seas were already occurring. At 1200 the SEA-LAND COMMERCE had 46-kn winds and 25-ft swells near 32.5°N, 156.5°E, and the OJI MARU (33.7°N, 163.4°E) reported 57 kn and 30 ft. On the 3d there were gales in the southwest quadrant; at 1200 the PACIFIC BEAR (36°N, 173°W) had westerly 45-kn winds with 33-ft swells.

Also at 1200, this LOW disappeared. A new one that was analyzed at 0000 took over farther north. The major circulation did not change much, only the center of it. On the 4th the LOW was 958 mb, and the

ASIA BEAUTY had 47-kn winds northeast of the center. The MONTIRON was at 46.5°N, 155.3°W, on the east side of a trough behind the front and measured 46-kn winds with 20-ft seas and 31-ft swells. At 0600 the JBDB (50°N, 142°W) fought 58-kn winds. At 1200 EB16 measured 54 kn. For that analysis this was the only closed LOW from Japan to California. Before and later, other LOWs cluttered the chart. This LOW disappeared near the Bering Strait by the 6th.

This storm began by the 0000 analysis of the 5th. It was one of the LOWs that broke up the single-LOW circulation of the 4th. At that time it was 971 mb near 41°N, 175°W. The AKADEMIK KOROLYOV, at 38°N, 180°, had 40-kn gales and 25-ft seas. The RACHEL (31°N, 178°W) was battered by 45-kn winds, 33-ft seas, and 41-ft swells. At 0600 the SHINYO MARU (34.3°N, 170.7°W) was blasted by 86-kn winds, and the KISO MARU nearby at 34.2°N, 170.5°W, suffered 64-kn winds.

The LOW raced northward. At 0000 on the 6th, it was near 50°N, 169°W, at 952 mb. The ASIA BEAUTY (54°N, 163°W) measured 55-kn winds with 33-ft seas. The WZFW (54.2°N, 163.2°W) reported 55-kn easterly winds, 49-ft seas, and 25-ft swells. The TOYOTA MARU No. 12, near 48°N, 160°W, had 50-kn southeasterlies and 20-ft waves at 0600. The LOW crossed into the Bering Sea on a northwesterly course, which changed to westerly on the 7th, and moved over northern Kamchatka to disintegrate on the 9th.

This was another of those wandering storms that turn westward. This one also turned eastward again. At 0000 on the 6th, it was at 38°N, 158°E. Minimum gale-force winds were blowing in the southern half of the circulation, but the ADRIAN MAERSK found 48-kn gales with 21-ft seas. The ASIA BEAUTY was north of a small, short-lived LOW to the north of this one; she measured 55-kn winds with 33-ft seas. On the 7th the BREWSTER encountered 55-kn measured winds about 400 mi southwest of the center. The INDIAN MAIL estimated 60-kn winds and 30-ft waves 600 mi south of the storm's center at 1200 and at 0000 on the 8th, had 26-ft swells on her stern near 36°N, 178°E. At 0600 the KINYO MARU, at 40.7°N, 177.2°W, had 55-kn winds and 33-ft waves. The PLUTOS had 30-ft seas and the INDIAN MAIL 26-ft swells.

At 0000 on the 9th, the 962-mb LOW was at 48°N, 171°W--its most easterly position. The PRESIDENT MADISON was taking 50-kn winds and waves to 30 ft. At 0600 the winds increased to 55 kn near 43.5°N, 151.4°E. There was an area south of the center between 30° and 37°N and 165° and 175°W where four ships all reported over 25-ft waves. There were winds of 50 kn both north and south of the storm's center on the 10th. At 1200 the UIGW fought 50-kn winds and 33-ft swells near 35°N, 178°E. The SUCCESSFUL VENTURE (38.4°N, 165.4°E) measured 53-kn winds and waves up to 26 ft on the 10th. On the 11th the UNION PROGRESS (32.5°N, 157.7°E) had 60-kn westerly winds. Late in the day the storm turned northward, then eastward again on the 12th. There was a large expanse of weak low pressure between three centers, and on the 13th the southeastern one took over the circulation.

A minor trough left over from a previous secondary low-pressure center was the impetus for this storm center. It was one of many that rotated around the primary LOW associated with the long wave circulation. At 1800 on the 14th the EXPORT COURIER was west of the trough at 35.5°N, 178.1°W, with 43-kn gales, but the swells were pounding at 33 ft. At 1200 on the 15th, the LOW was 966 mb near 43°N, 160°W. The LEO was northeast of the center at 48°N, 155°W, and measured 50-kn winds with 30-ft seas. Far to the south along latitude 29°N a ship battled 30-ft swells. By 0000 on the 16th, the LOW was 946 mb near 47°N, 156°W. The OLGA TOPIC was 500 mi away in the southeast quadrant with 30-ft seas. The cyclonic circulation extended from coast to coast and south to 23°N. Along the cold front a ship at 29°N, 168°W, was hit by 75-kn winds and 30-ft swells. Farther to the northeast, also along the front, the STREAM HAWSER found 33-ft swells at 33°N, 161°W.

The CROWN PEARL, a 5,450-ton freighter, with a cargo of logs sustained a cracked hatch about 300 mi northwest of Midway Island. The vessel was taking on water and listing heavily. The crew abandoned ship and were rescued by the ROMANDIA (20,797 tons) which proceeded to Kobe. The ASIA LOYALTY put a line on the drifting CROWN PEARL on the 21st and commenced towing the abandoned vessel to Honolulu. About 500 mi from Honolulu on the 23d, the CROWN PEARL sank.

The AKADEMIK SHIRSHOV was near the British Columbia coast with 82-kn winds from the south and 23-ft waves.

The storm was centered near 56°N, 157°W, at 0000 on the 17th. The CHEVRON MISSISSIPPI (55.5°N, 146.3°W) had 50-kn easterly winds. At 0600 the ALASKA STANDARD had 55 kn near 58°N, 152°W. By 1200 this LOW absorbed the major circulation center, which had been weakening, and became the major center. The whole system was filling, and the gradient was relaxing with mostly minimum gales. On the 18th the center was on a westerly track, which meant the end was near for this center.

The major circulation still existed, and it was the only cyclonic center from Asia to North America. There was an anticyclonic circulation associated with a high-pressure center over the western United States. There were three trough lines in the cyclonic circulation spaced between Necker Island and Marcus Island. At 0038 on the 18th, the 21,090-ton Liberian tanker IRENES CHALLENGER sent an SOS and was sinking about 200 mi southeast of Midway Island. She had broke in two (fig. 52). The PACIFIC ARROW rescued 28 of the 31 crewmen. Three who remained on board were missing. Weather conditions in the area were reported as extremely bad, but winds of around 40 kn and waves up to 20 ft were the highest indicated on the charts.

This was another short-wave LOW. It began on the 18th and traveled around the periphery of the major circulation described above. It moved basically eastward, bringing only wind shifts to ships in its path until the 20th when it was 974 mb near 44°N, 164°W. At 0000 the 7JBL found 70-kn winds near 45°N, 170°E. At 1200 the HAKUSAN MARU (42.5°N, 164.8°W), about 100 mi southwest of the center, fought continuous

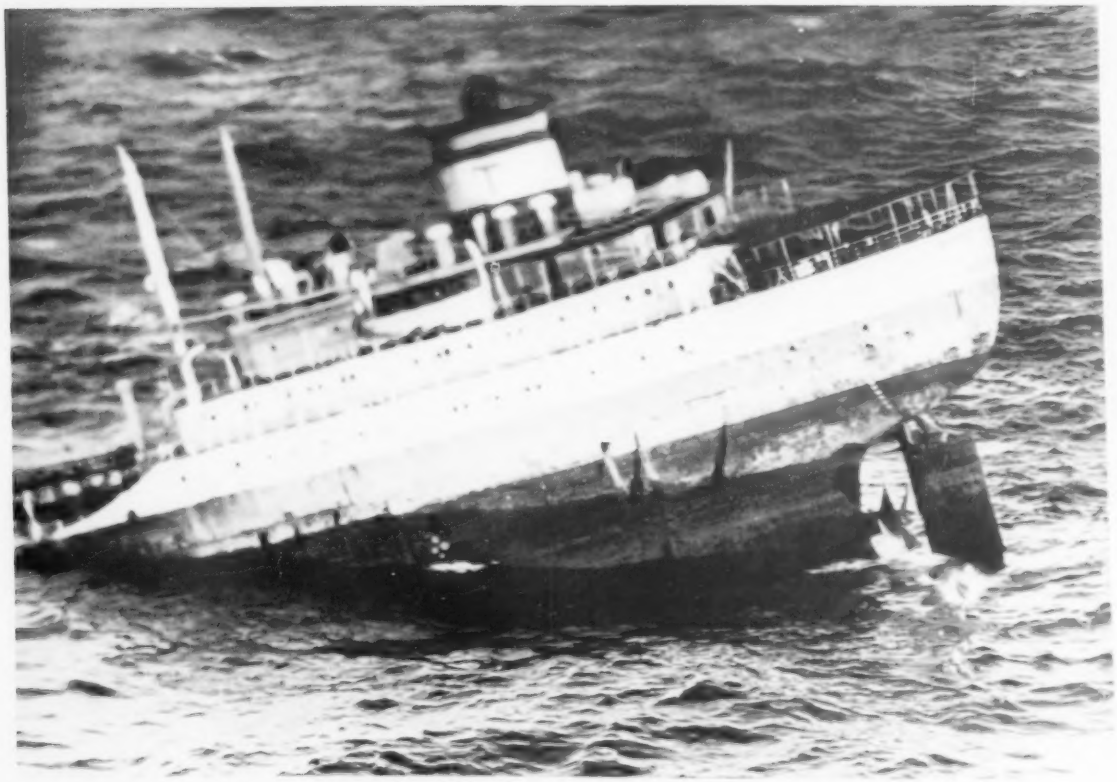


Figure 52.--The stern of the 600-ft oil tanker IRENES CHALLENGER sticks out of the water after she broke in two southeast of Midway Island.

heavy rain with 60-kn winds and 21-ft waves. At 1800 the winds were still 60 kn but shifted to the west. By the 21st the LOW had combined with another.

This minor LOW, which started at 1012 mb south of Shikoku on the 23d, became the major long-wave LOW. For the first few days it raced eastward under the influence of the zonal winds. On the 24th at 0000, it was already 988 mb near 35°N, 153°E. The HONG KONG MAIL found 70-kn northerly winds on one report at 34.5°N, 151.8°E, and 25-ft seas and swells at 34.3°N, 150°E, on another. The ASIA BOTAN was hit by 60-kn winds near 34°N, 159°E. At 0600 they increased to 72 kn, and the EATON GLORIA at 32°N, 152°E, fought 63-kn winds and 33-ft seas and swells.

At 0000 on the 25th, the LOW was expanding and deepening rapidly to 962 mb near 38°N, 172°E. The ASIA BOTAN was gingerly continuing on her easterly track with 100-kn northwesterly "winds." The swell was 33 ft. Several other ships in the vicinity radioed 60-kn winds. The 50- to 60-kn winds continued with 30 ft the highest wave reported. South of the low center was a bad place to be caught. At 0000 on the 26th, the ASIA BOTAN was still experiencing 80-kn winds. The ERIKA BOLTEN, at 36°N, 171.5°W, was headed into 64-kn west-southwesterly winds with 39-ft seas. At 37.3°N, 175°W, the ARNOLD MAERSK was headed into 56-kn westerly winds and what was coded as 62-ft seas. Six hours later, the BOLTEN had only 33-ft seas, and the swells pounding the MAERSK were 54 ft.

The LOW, now tracking northeastward, was the major cyclonic circulation over this ocean. On the 27th, its influence stretched from Alaska to 20°N. Maximum reported winds were in the 50-kn category. and the highest waves were 36 ft. The lowest pressure was 952 mb. By the 28th the storm was weakening, and another was on its heels trying to catch up. A Japanese-registered ship reported 36-ft swells near 45°N, 175°W. The ARNOLD MAERSK was following the LOW eastward with 30-ft seas 700 mi south of the center. Early on the 29th the new two-center storm to the west took the lead, producing winds measured to 50 kn and seas and swells in the 30-ft range.

Casualties--The fishing vessel SALU sank off Kodiak Island in heavy weather on the 3d. The crew was rescued. The jack-up rig SCAN SEA encountered heavy weather during a relocation in the South China Sea and capsized. All crewmembers were disembarked or picked up and taken to Singapore. The Japanese squid boat DAIMARU No. 2 went aground on the west coast of South Island, New Zealand, on the 4th. All 13 crewmen were rescued by helicopter in gale-force winds. The 1,210-ton Philippine-registered DON

RENE grounded on Pratas Reef on the 11th in a heavy gale and a hold flooded. All crewmembers were rescued and transferred to the container vessel ISLAND CONTAINER.

The WORLD PELAGIC was 4 days out of Everett, Wash., when at daybreak the cargo logs were found to have shifted with 2,000 logs weighing 830 tons lost overboard. Listing to starboard with logs hanging over the side, the vessel proceeded to Dutch Harbor arriving 2 days later. Low temperatures had coagulated part of the ship's fuel. Men and equipment were flown in; and on the 23d in high winds, freezing temperatures, large swells, and sleet and snow, restorage of the cargo was started; and the vessel sailed on the 28th.

SMOOTH LOG, FEBRUARY 1977--The primary area of cyclogenesis this month was shifted to the east-central ocean along approximately 40°N from 180° to 150°W. These storms generally tracked northeastward then northward into the western Gulf of Alaska, some curving northwestward. Those storms that formed in the area of Japan had more easterly tracks than normal and were sparce--averaging only about one per week.

This shift in storm tracks was reflected in the mean pressure. A 984-mb Aleutian Low was centered at 53°N, 170°W. This was 15 mb lower than the climatic 999-mb Low near 50°N, 180°, and another 1000-mb Low 10° longitude to the west. The Pacific High off the California coast was normally located near 30°N, 130°W, but it was 6 mb higher in pressure at 1026 mb. The high pressure cell normally centered over the northwestern United States was also 6 mb higher in pressure at 1025 mb.

The shifting of more intense pressure centers resulted in one large negative anomaly of 19 mb and two positive centers of 5 and 6 mb. The negative anomaly was centered near 55°N, 168°W, and dominated the ocean shore to shore north of latitude 30°N, except off the U.S. West Coast. The positive 5-mb center was near 34°N, 128°W, off the California coast and the 6-mb center was north of the Great Salt Lake.

The upper-air center of circulation was shifted from the Kamchatka Peninsula to over Adak Island and over 100 m lower in height for the 700-mb surface. The ridge over the Rocky Mountains was much sharper than normal causing a strong, cold northwesterly flow over the central and eastern United States.

Extratropical Cyclones--A large LOW developed over the central ocean the last day in January and continued deepening. At 1200 on February 1, the MEDELENA measured 45-kn winds, 15-ft seas, and 25-ft swells on the southern periphery of the large cyclonic flow near 36°N, 178°W. By 0000 of the 2d, the LOW was 950 mb near Unimak Island. On that analysis a secondary LOW formed 700 mi to the south near 44°N, 166°W. This quickly tightened the gradient south of that latitude. The MEDELENA was 550 mi to the southwest and was caught by 80-kn hurricane-force winds with 16-ft seas. The CRYSTAL REED was 300 mi southeast of the 966-mb center, just east of the front and sailing with 30-ft seas and swells pounding her starboard side. On the 3d the LOW was absorbed into the main circulation. On the 4th the ANCO DUKE was caught by 45-kn winds, 41-ft waves, and 36-ft swells as a minor trough passed 35°N, 153°W. On the 5th she still was being beaten by 25-ft seas and 33-ft swells.

As the previous storm died, another was born near 30°N, 155°E, as a frontal wave. In 24 hr it raced 20° longitude to the east and was 990 mb at 0000 on the 4th. By 1200 the 978-mb LOW had raced slightly north of a ship near 40°N, 178°W, with 65-kn winds. Back toward the east another LOW had formed and treated the KHALIDIA to 90-kn winds. On the 5th the SANKO-LIGHT was north of the deteriorating subcenter and west of the major center with 50 kn. The ATLANTIC PHOENIX was west of the eastern subcenter, which was also being squeezed out of existence, with 72-kn winds. At 0600 her winds were only 55 kn, but at 1200 they were back up to 68 kn.

Late on the 5th, the LOW traveling south of the main LOW was only a minor trough in the overall pressure pattern, but it remained identifiable until midday on the 6th. The routing of the ANCO DUKE was taking her from one storm into another, and she now suffered 60-kn winds with 26-ft swells. As these minor LOWs and troughs fed toward and into the Gulf of Alaska, the pressure gradient fluctuated rapidly. The ASIA BEAUTY measured 52-kn winds driving 17-ft seas and 33-ft swells off Vancouver Island.

The point of occlusion on a front was the point of origin of this storm. It was first analyzed on the 0000 chart of the 6th at 982 mb. Twelve hours prior to this, the circulation was more zonal and a ship in the area reported 28-ft swells. The FEDERAL NAGARA had 45-kn winds along the front. By 1200 on the 6th, the central pressure had plunged to 961 mb as the storm moved on a northeasterly track to 42°N, 178°E. There were several reports of 16-ft swells southwest of the center. In the next few hours, the JAPAN RAINBOW, KASUGAT MARU, and OPHELIA were to suffer winds in the 60-kn and waves in the 30-ft category to the north, west, and south of the center.

At 1200 on the 7th, the pressure dropped to 948 mb as the storm center approached Adak Island. The KASUGAI MARU continued to have 60-kn winds and 30-ft waves until the 8th. At that time the JAPAN RAINBOW reported 72-kn winds. The MORNING GLORY was sailing eastward along 48°N, and her equipment measured 52-kn winds, with 16-ft seas, and swells up to 21 ft on the 8th and 9th.

At 0000 on the 9th, this was the only cyclonic circulation over the northern ocean. By 1200 a subcenter had formed in a trough line south of the primary low center. The POST CHAMPION was between the two centers near 48°N, 176°W, with 86-kn westerly winds. No seas were reported. Two fishing vessels north of the center near 60°N had freezing 50-kn northeasterly winds.

On the 10th the storm was weakening and only minimal gales were reported. Other LOWs were forming and dissipating on the periphery of the primary circulation. On the 12th the storm no longer existed as another took its place.

Monster of the Month--This was one of two storms that formed south of Japan during the month. It raced eastward at up to 60 kn. The LIVERPOOL CLIPPER was south of the front early on the 11th with 50-kn winds. A Japanese-registered ship, 400 mi southeast of the fast-moving center, logged 30-ft swells. Later on the 11th, the KYOMEI MARU, 600 mi south of the 980-mb LOW and 300 mi west of Midway Island, rode out 26-ft seas.

On the 12th the 956-mb LOW slowed in its plunge eastward, and the winds and waves increased. Near the center, which was at 44.5°N, 169.5°W, the JAPAN BEAR fought 60-kn winds, 16-ft seas, and 33-ft swells after the LOW passed nearly directly over the ship. The JAPAN RAINBOW was slowly sailing westward and passed very near the center of the LOW with 50-kn winds near 41°N, 176°E, on the west side of the LOW. Five hundred miles south of the center, the NANSHO MARU was pounding into 41-ft waves.

About 1,000 mi southwest of the LOW, there was a band of gale-force winds. The LIVERPOOL CLIPPER was caught in this area. Near 33°N, 158°E, she was headed into 33-ft seas and 49-ft swells. At 0600 the JAPAN BEAR had 49-ft swells pounding her port quarter, and they were still 33 ft at 1200. At the same time, Ocean Weather Station Papa measured 46-kn winds and 33-ft seas. At 1800 her winds increased to 80 kn.

The ROSE S sank on the 12th after sending a distress message that she was taking water in the forward hold. At the time she was about 1,200 mi off Midway Island on a voyage to Japan with a cargo of logs and scrap iron. The GLOBAL FRONTIER reported on the 13th that it had sighted drifting logs. An oil slick and deflated liferaft were also found in the area. There was no sign of the 31 crewmen. At 0000 on the 12th, the ROSE S sent a weather report from 31.1°N, 163.6°E, of 38-kn northwesterly winds and 18-ft seas and swells. At the same time the LIVERPOOL CLIPPER reported 33-ft seas and 49-ft swells about 300 mi west-northwest of her position.

Also on the 12th in the Gulf of Alaska, the GREAT LAND heard a Mayday distress signal from the fishing vessel SNOWBIRD enroute to Seattle. Severe weather conditions with swells up to 25 ft had damaged the SNOWBIRD's wheelhouse causing loss of steering and main engines. The GREAT LAND escorted SNOWBIRD to Dixon Entrance where they were met by the U.S. Coast Guard cutter LAUREL. A small LOW had spun off the east side of the main LOW on the 11th and was over the Gulf of Alaska at the time; it dissipated on the 13th.

On the 13th the GRAND CARRIER (36°N, 165°W) was washed by heavy rain driven by 65-kn winds as a trough line approached. The high winds had moved to the northeastern quadrant as this storm caught up with another in the Gulf of Alaska. There were four reports in the 50-kn category in the vicinity of 52°N, 140°W. The waves were in the 20- to 30-ft range. Later on the 13th, the high windband (50 kn) had rotated into the northern quadrant and battered the Soviet fishing fleet in the Bering Sea. Swells up to 25 ft were still found south of the center. On the 14th the CORAL ARCADIA was headed toward Seattle near 51°N, 134°W, with 76-kn southerly winds.

On the 15th the LOW crossed into the cold Bering Sea and rapidly lost its punch.

This was the other storm that was produced by the waters south of Japan. It was first noticed on the analysis of 0000 on the 14th. It did not move as fast as its earlier mate, but it deepened quicker. The CRESSIDA at 38°N, 148°E, was northwest of the center at 1800 on the 15th moving into 50-kn winds, 26-ft seas, and 30-ft swells. At 0000 on the 16th, the center was 984 mb at 40°N, 161°E. The CRESSIDA now had 23-ft seas and 28-ft swells pounding her port side. The JAPAN RAINBOW was having a rough voyage, sailing from one storm into another. She reported 70-kn northeasterly winds north of an east-west oriented trough west of the LOW. There were reports of 50 to 60 kn south of the center and a report of 30-ft seas. At 1200 the KODO MARU (35°N, 157°E) had 55 kn. On the 17th, LOWs formed both to the east and west of this storm. By 1200 they had taken over the circulation, but at 0000 the 980-mb LOW was still producing 50-kn winds and waves to 25 ft.

Both of these LOWs produced high winds and seas. On the 17th, the western LOW was 996 mb near 38°N, 154°E. The HANS SACHS, 400 mi southwest of the center, braved 52-kn westerly winds and 30-ft seas and swells. Others were finding the same winds as far as 1,000 mi west of the center. On the 18th the KASHU MARU, only 60 mi south of the center, was pounded by 53-kn winds and 31-ft swells.

The 19th was a bad day to be in the area of 180° south of 42°N. The VAN HORNE was 100 mi south of the low center at 0000 with 50-kn winds and 39-ft seas and swells. Four hundred miles to the south, the SANG JIN also fought 50-kn winds with 30- and 33-ft seas and swells, respectively. By 1800 the LOW was only indicated by a dip in the circulation.

Back again to the 17th. The eastern LOW deepened rapidly, which increased the pressure gradient. A ship along the front reported southerly 30-ft swells. On the 18th the pressure was 954 mb at 1200 near 46°N, 153°W. The CRYSTAL REED was caught with 50-kn winds and 33-ft seas and swells near 35°N, 152°W, at frontal passage. OWS Papa had 20-ft seas on the 19th, and another ship south of her had 25 ft. Late in the day the center crossed into western Alaska.

Rather than degenerate into a trough, this LOW developed from a trough line. At 0600 on the 19th, a closed circulation formed in the sharpest area of curvature. At 1200 the winds were blowing at better than 40 kn with one report of a heavy thunderstorm. At 1800 the

CHALMETTE (35°N, 159°W) was treated to 60-kn winds. At 0000 on the 20th, there appeared to be a convention of ships near 40°N, 145°W. Five ships in the area reported winds between 45 and 50 kn. The waves were 25 to 30 ft.

The LOW reached its lowest pressure of 946 mb on the 20th near 47°N, 148°W. At 1800 there were six ships with winds over 50 kn and seas to 25 ft mostly south of the center. The storm was over the Gulf of Alaska and raising havoc with shipping. High-wind reports stretched from 37°N to 56°N. The YEH YUNG reported 49-ft swells near 48°N, 137°W. Another ship had 39 ft near 41°N, 132°W. At 0600 on the 21st, OWS Papa measured 50-kn westerly winds and 34-ft seas. The USNS SEALIFT PACIFIC had 60-kn winds from 160° near 49°N, 132°W. At 1200 she reported seas of 36 ft, while Papa still had 30-ft seas.

Another small center formed off the coast of Washington bringing beneficial rains as far south as central California and high winds and surf to the Oregon and Washington coasts. Gusts reached 52 kn along Oregon and 85-kn gusts were observed on Vancouver Island. Swells pounding the coast were up to 20 ft.

On the 22d the SEALAND FINANCE (50.5°N, 140.5°W) was mauled by 16-ft seas and 33-ft swells. The center of the storm was tracing a counterclockwise loop off Kodiak Island on the 22d and 23d and finally disappeared.

As a front moved over Japan late on the 20th, a wave formed near Tokyo. Its circulation broadened and it deepened rapidly. By 0000 on the 22d, it was 958 mb near 47°N, 160°E. The QUEENSWAY BRIDGE was about 120 mi southeast of the center with 60-kn winds from the south and 20-ft seas. The SHOZUI MARU, about 180 mi southwest of the center, had 47-kn winds from the northwest and 30-ft seas. In 6 hr, the QUEENSWAY BRIDGE only made about 30 mi on her westerly track as the seas increased to 33 ft. The 5LXR was about 180 mi to the north with 70-kn northwesterly winds and 39-ft seas.

At 0000 on the 23d, the central pressure had dropped to 940 mb, and the EHIME MARU and two other ships fought winds of 60 kn or more and waves to 33 ft. The TAEPING was swamped by 49-ft seas near 53°N, 180°, at 1200. The seas were still 39 ft on the 24th. Many other ships were reporting winds in the 50-kn and seas in the 25-ft category. These general conditions continued into the 24th, but late that day the storm was weakening over the Bering Sea. On the 24th the center curved westward and then southward on the 25th and 26th. It was still a very large storm on the 25th when the ORIENTAL EDUCATOR fought 65-kn westerly winds far to the south near 36.5°N, 174.5°E. The swells were 33 ft.

During the period of the 23d to the 28th, the SHUNWIND was traveling from near Attu Island to Yoko-

Figures 53 to 56.--These four pictures show the heavy ice on the bow of the SHUNWIND. The cadet is Law Tak Fai. Photos by Chief Officer Tang Ko Man.

hama on the western edge of this large cyclone. During this period the winds were generally gale force with the highest seas 21 ft and swells 23 ft. On the 23d while west of Attu, the winds were measured at 50 kn with the temperature 0°C. As the ship proceeded southward, the windspeed dropped as did the temperature. From 1500 on the 23d to 1200 on the 28th, the cold air off the Asian mainland was 3° to 6°C below freezing as the ship sailed southwestward about 150 mi off the Kurile Islands. Figures 53 to 56 show the vast amount of ice deposited on the SHUNWIND during this time. The crew estimated 500 tons on the foredeck. The Port Meteorological Officer reports that the SHUNWIND has been an excellent weather reporter since her maiden voyage. She has submitted over 180 weather observation logs.

The initial wave of this storm had its origin over the Gobi Desert. It was in a hurry to leave that cold, desolate area and moved over the Sea of Japan by 1200 on the 28th. On March 1, it was 996 mb off Hokkaido. The ALASKA MARU was about 60 mi south of the center with 40-kn southwesterlies. Later in the day, ships reported 50-kn winds. On the 2d it was on its way to becoming the primary circulation. The PRESIDENT FILLMORE was battered by 26-ft waves. A Japanese ship was pounded by 50-kn winds and 33-ft swells far ahead of the storm.

On the 3d, the 976-mb LOW was near 52°N, 172°W. The KLAK was near 54.1°N, 146.9°W, with 50-kn winds from the southwest, 41-ft seas, and 57-ft swells. Fifty- to sixty-knot winds continued into the 4th. The LOW was traveling along the Aleutian Islands and was over the Gulf of Alaska on the 4th. On the 5th it moved inland and was no longer a threat.

Casualties--The PRESIDENT LINCOLN (13,265 tons) suffered side-shell plate damage at Keelung on the 2d as a result of contact with tugs and wharf during heavy weather. The 11,170-ton Taiwanese YEH YUNG lost containers overboard during heavy weather on the 6th. The Kuwait-registered tanker BORAG (21,616 tons) grounded on rocks at 25.2°N, 121.7°E, on the 7th. Heavy weather caused pounding damage and the vessel sank on the 15th. The crew was safe. The Panamanian-registered freighter TRIUMPH No. 1 (8,342 tons) developed a leak in bad weather on the 22d and 23d and sank about 480 mi east of Japan. All crewmembers were rescued by the TORA MARU.

The Japanese-registered TOCAMA MARU (18,855-tons) reported that she had developed a leak in 35-ft seas while 200 mi south of the Aleutian Islands on the 22d.

The 45,246-ton Liberian-registered HAWAIIAN PATRIOT (fig. 57) sustained a large crack in the hull during a storm on the 23d causing heavy leakage of oil. As the vessel drifted, the oil ignited, and the subsequent explosion engulfed the ship in flames. It broke in two and sank near 22°N, 165.5°W, on the 25th. All crewmembers were saved, except one.

The 2,431-ton American tank barge sank during heavy weather on the 25th near 24.4°N, 112.3°W, while under tow by the tug MOANA HOLD.

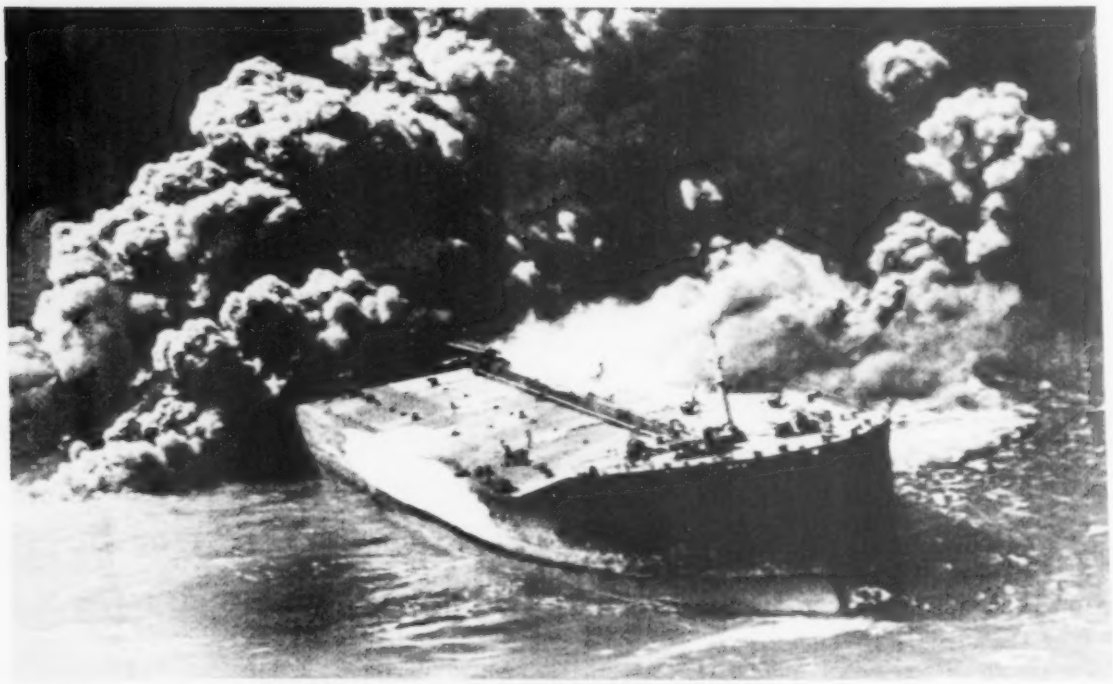


Figure 57.--The bow of the tanker HAWAIIAN PATRIOT juts from the billows of black smoke. Wide World Photo.

Principal Tracks of Centers of Cyclones at Sea Level, North Pacific

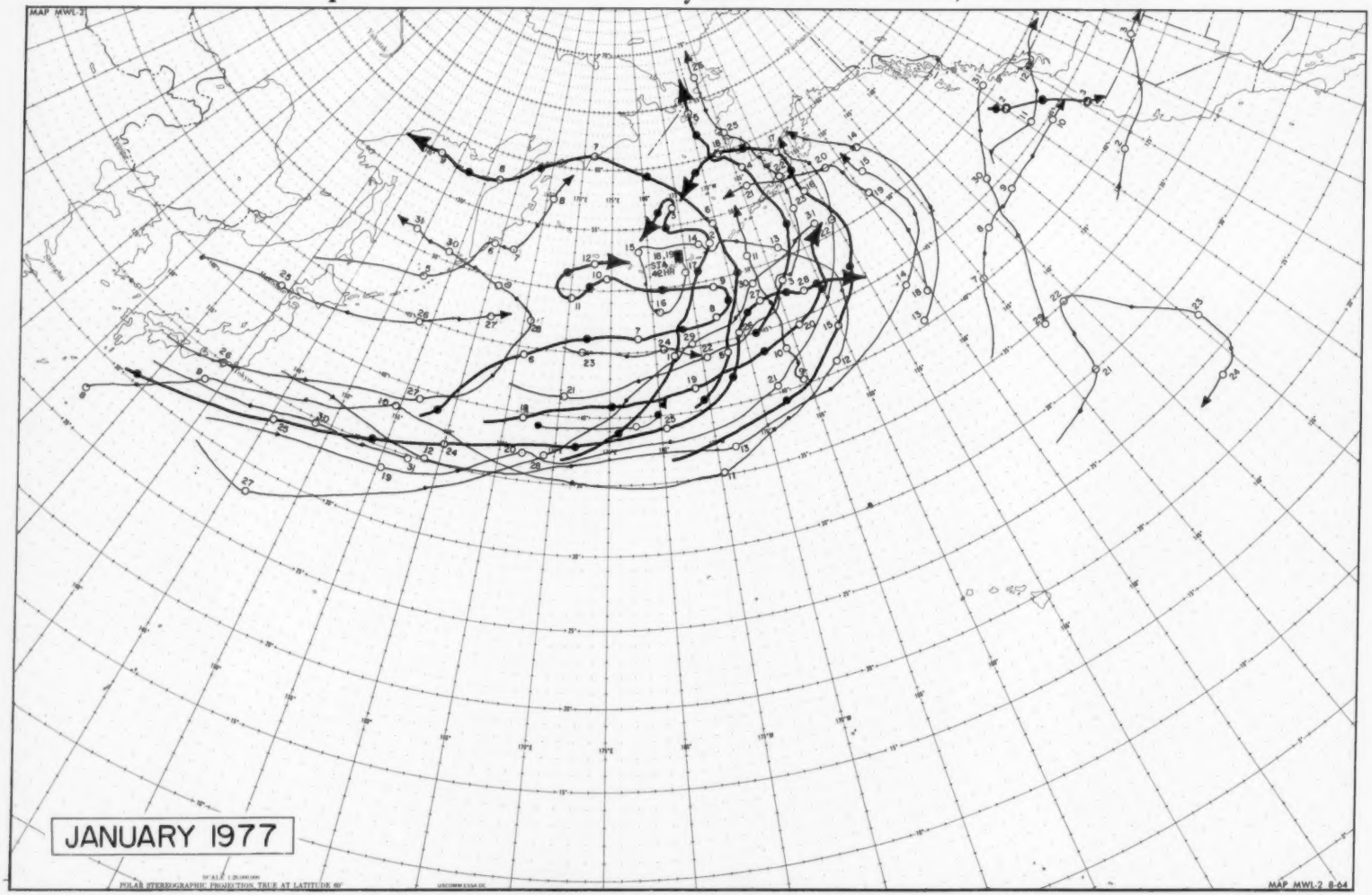


Figure 58. --Open circle indicates 1200 GMT position and closed circle 0000 GMT position. Square indicates stationary center. Cyclone tracks marked with a heavy line are described in the Smooth Log.

Principal Tracks of Centers of Cyclones at Sea Level, North Atlantic

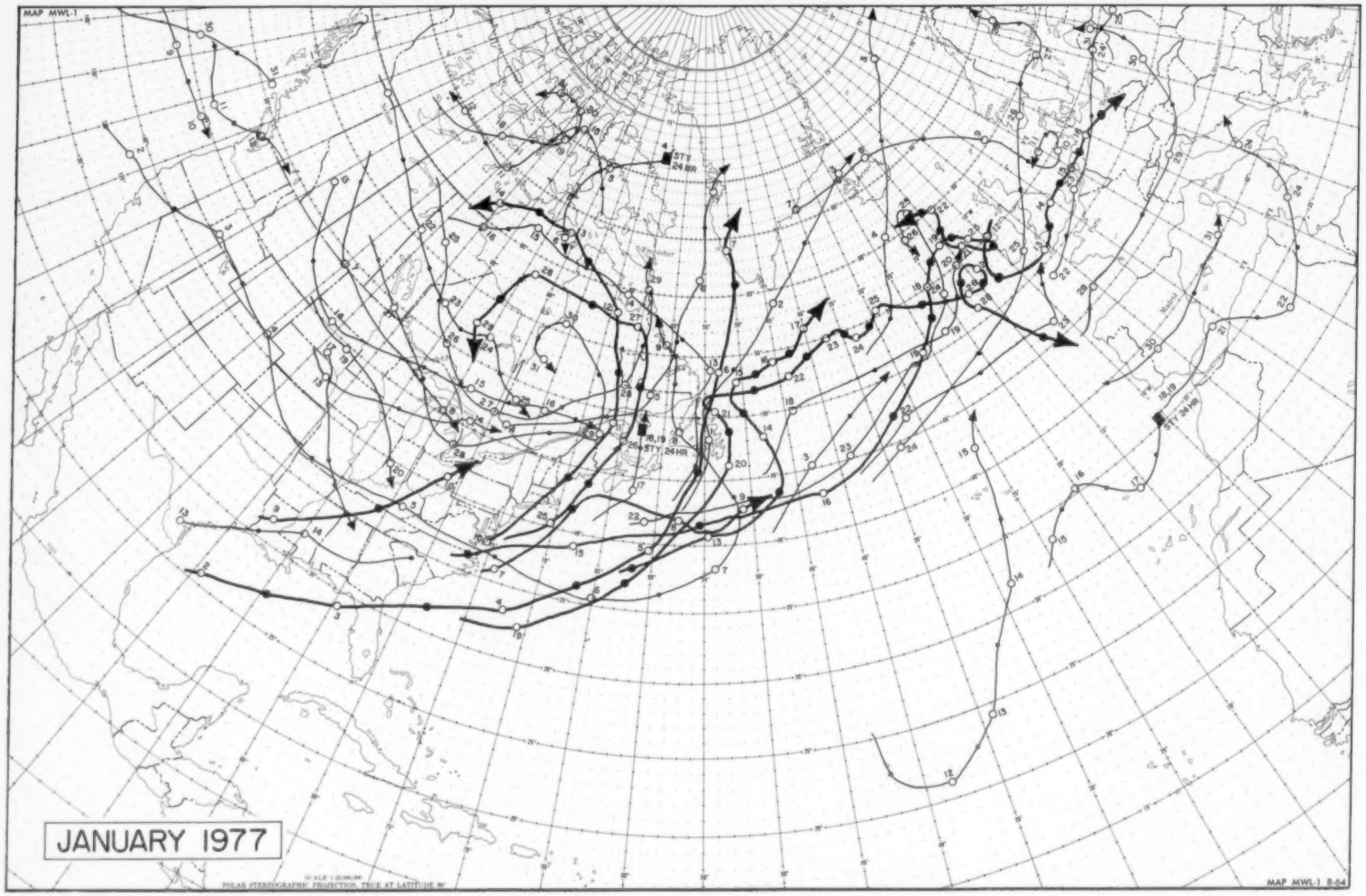


Figure 59. --Open circle indicates 1200 GMT position and closed circle 0000 GMT position. Square indicates stationary center. Cyclone tracks marked with a heavy line are described in the Smooth Log.

Principal Tracks of Centers of Cyclones at Sea Level, North Atlantic

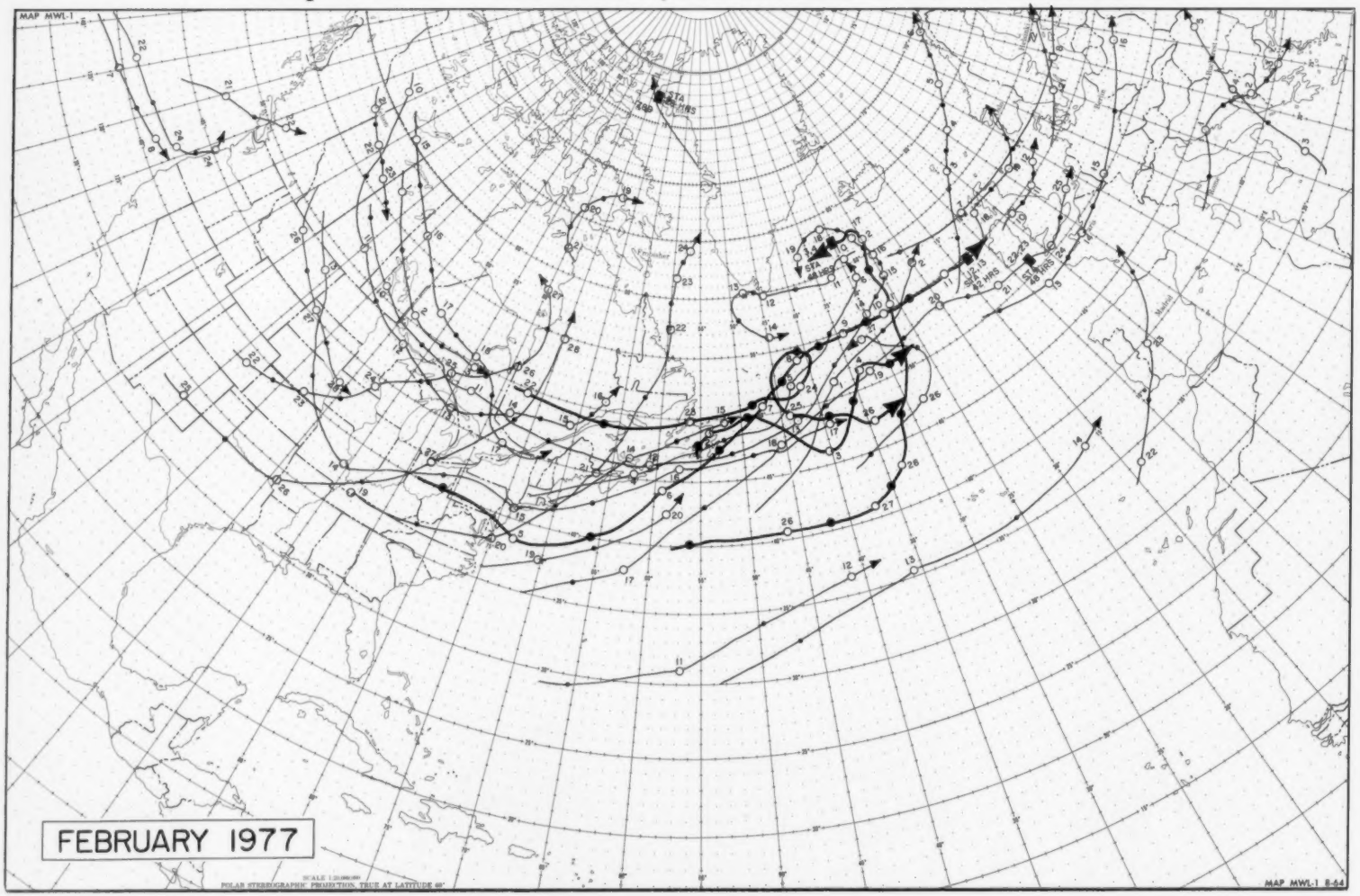


Figure 60. --Open circle indicates 1200 GMT position and closed circle 0000 GMT position. Square indicates stationary center. Cyclone tracks marked with a heavy line are described in the Smooth Log.

Principal Tracks of Centers of Cyclones at Sea Level, North Pacific

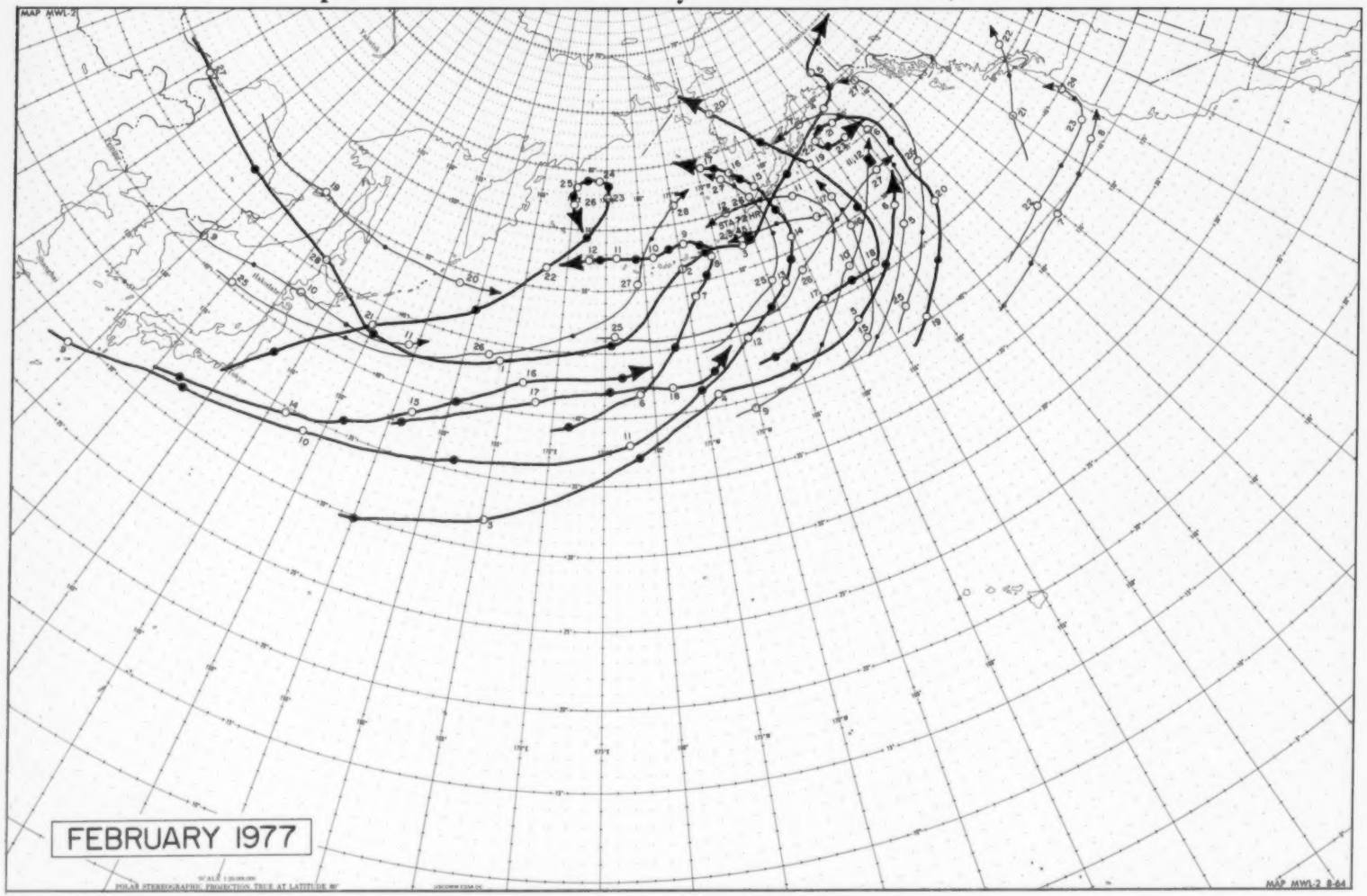


Figure 61. --Open circle indicates 1200 GMT position and closed circle 0000 GMT position. Square indicates stationary center. Cyclone tracks marked with a heavy line are described in the Smooth Log.

Table 6
U. S. Ocean Weather Station Climatological Data, North Atlantic

Ocean Weather Station 'HOTEL' 38°00'N 71°00'W **January and February, 1977**

MEANS AND EXTREMES

MONTH	DRY BULB TEMP (°C) MIN	DA HR	MEAN	MAX	DA HR	DEW-POINT TEMP (°C) MIN	DA HR	MEAN	MAX	DA HR	SEA TEMP (°C) MIN	DA HR	MEAN	MAX	DA HR	AIR-SEA TEMP DIFFERENCE (°C) MIN	DA HR	MEAN	MAX	DA HR
JAN	- 4.4	17 15	5.6	18.1	10 18	- 7.2	17 21	.9	13.4	10 18	9.5	29 18	13.0	24.4	12 15	-19.1	12 15	- 8.0	3.9	10 18
FEB	- .7	06 09	10.8	20.4	28 00	- 4.6	07 12	5.2	18.1	*28 06	17.4	23 00	20.5	22.7	03 21	-20.7	06 18	- 9.7	.2	25 03

MEANS AND EXTREMES — PRESSURE (MB)

MONTH	MIN	DA HR	MEAN	MAX	DA HR
JAN	989.4	07 18	1011.2	1030.3	13 15
FEB	989.0	05 15	1013.9	1028.8	*09 03

PERCENTAGE FREQUENCY OF CLOUD AMOUNT (OKTAS)

MONTH	TOTAL CLOUD 0-2	3-5	6-7	8 & OBSC	LOW CLOUD 0-2	3-5	6-7	8 & OBSC
JAN	2.9	5.7	34.7	56.7	11.8	13.1	40.0	35.1
FEB	18.8	17.4	37.9	25.9	29.9	19.6	36.2	14.3

DAYS WITH SPECIFIED WEATHER

MONTH	RAIN OR PCPN	DRZL	SNOW	TSTM	VSBY <1KM **	WIND (KTS) ≥34	≥48	≥64	COMP OB DAYS	SOBS WITH PCPN	NO OF OBS
JAN	27	27	15	3	2	18	8	2	30	30.8	245
FEB	16	16	8	1	4	15	2	3	28	19.2	224

** VV-90-93 AND/OR W-4 COMP OB DAYS-COMPLETE OB DAYS

Wind

JAN — WIND DIRECTIONS AND SPEEDS (% FREQUENCIES)

DIR	WIND SPEED (KNOTS) <4	4-10	11-21	22-33	34-47	>47	TOTAL	MEAN SPEED
N	.4	1.7	5.3	3.6	.7	.0	11.9	19.5
NE	.0	1.6	2.0	.8	.0	.0	4.5	14.6
E	.0	3.1	1.3	.3	.0	.0	4.7	10.8
SE	.0	.4	1.1	.2	.0	.0	1.7	13.8
S	.0	.0	.8	1.7	.8	.8	4.2	33.0
SW	.0	.9	.4	.2	.7	.1	2.3	29.3
W	1.0	1.9	4.3	4.9	4.2	.7	17.0	24.9
NW	1.0	2.6	7.8	23.4	16.8	2.0	53.6	29.1
CALM	.0	.0	.0	.0	.0	.0	.0	.0
TOTAL	2.4	12.2	23.3	35.1	23.3	3.7	100.0	25.5

NUMBER OF OBS 245 — MAX WIND DIR SPEED DA HR 2?0 ?0 2? 1?22 — VECTOR MEAN SPEED 18.8 DIR 308 (DIR IN DEGREES)

FEB — WIND DIRECTIONS AND SPEEDS (% FREQUENCIES)

DIR	WIND SPEED (KNOTS) <4	4-10	11-21	22-33	34-47	>47	TOTAL	MEAN SPEED
N	.0	1.9	.7	.3	.0	.0	2.9	12.3
NE	.4	.4	.0	.0	.0	.0	.9	4.3
E	.4	.0	.0	.0	.0	.0	.4	3.0
SE	.0	.4	1.3	.0	.0	.0	1.8	13.5
S	.9	.0	2.1	2.7	.4	.0	6.1	20.5
SW	.0	3.2	4.6	2.9	3.3	.0	14.1	23.2
W	.0	4.0	10.9	10.2	6.7	.4	32.3	24.2
NW	.0	3.8	13.8	15.6	4.0	.4	39.7	23.7
CALM	1.8	.0	.0	.0	.0	.0	1.8	.0
TOTAL	3.6	13.8	33.5	31.7	14.9	.9	100.0	22.4

NUMBER OF OBS 224 — MAX WIND DIR SPEED DA HR ?*0 ?? 2 2?10 — VECTOR MEAN SPEED 17.1 DIR 282 (DIR IN DEGREES)

Wave

JAN — WAVE DIRECTIONS AND HEIGHTS (% FREQUENCIES)

DIR	WAVE HEIGHT (METERS) <1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	TOTAL
N	.0	1.9	2.1	3.3	1.0	.0	.0	.0	8.4
NE	.0	4.2	1.0	.0	.0	.0	.0	.0	5.2
E	.0	1.2	.3	.0	.0	.0	.0	.0	1.5
SE	.0	.7	.6	.0	.0	.0	.0	.0	1.3
S	.0	1.0	2.4	1.2	.4	.4	.4	.0	5.9
SW	.0	1.8	2.4	1.9	.8	.1	.4	.0	7.6
W	.0	4.3	2.9	5.2	1.5	.7	1.1	.0	15.9
NW	.4	5.8	9.0	13.7	12.6	0.1	1.7	.0	49.3
IND	.0	4.1	.8	.0	.0	.0	.0	.0	4.9
CALM	.0	.0	.0	.0	.0	.0	.0	.0	.0
TOTAL	.4	25.3	21.6	25.3	16.3	7.3	3.7	.0	100.0

NUMBER OF OBS 245 — IND-INDETERMINATE

FEB — WAVE DIRECTIONS AND HEIGHTS (% FREQUENCIES)

DIR	WAVE HEIGHT (METERS) <1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	TOTAL
N	.0	.7	.3	.3	.0	.0	.0	.0	1.3
NE	.0	.0	.0	.0	.0	.0	.0	.0	.0
E	.0	.0	.0	.0	.0	.0	.0	.0	.0
SE	.4	.9	.0	.0	.0	.0	.0	.0	1.3
S	.3	2.7	1.9	1.9	.4	.0	.0	.0	7.3
SW	1.5	7.8	3.0	2.7	1.0	.0	.0	.0	16.0
W	1.3	8.4	7.3	10.7	3.5	.4	.0	.0	31.6
NW	.4	7.7	11.2	12.1	4.0	2.2	.0	.0	37.6
IND	.9	2.2	1.3	.0	.0	.0	.0	.0	4.3
CALM	.4	.0	.0	.0	.0	.0	.0	.0	.4
TOTAL	3.4	30.4	23.0	27.7	8.9	2.7	.8	.8	100.0

NUMBER OF OBS 224 — IND-INDETERMINATE

JAN — WAVE PERIODS AND HEIGHTS (% FREQUENCIES)

PERIOD IN SECONDS	WAVE HEIGHT (METERS) <1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	TOTAL
<6	.4	11.0	9.0	9.0	.0	.0	.0	.0	29.4
6-7	.0	9.0	10.2	12.7	10.2	.0	.0	.0	42.0
8-9	.0	1.2	1.2	3.7	3.3	1.6	1.2	.0	12.2
10-11	.0	.0	.4	.0	2.0	3.3	.8	.0	6.5
12-13	.0	.0	.0	.0	.8	2.4	1.6	.0	4.9
>13	.0	.0	.0	.0	.0	.0	.0	.0	.0
IND	.0	4.1	.8	.0	.0	.0	.0	.0	4.9
TOTAL	.4	25.3	21.6	25.3	16.3	7.3	3.7	.0	100.0

NUMBER OF OBS 245 — MAX WAVE HEIGHT HGT 8.0, PER 9, DIR 300, TYPE SEA, DA HR 08 03 — IND-INDETERMINATE (DIR IN DEGREES)

*ALSO OCCURRED ON PREVIOUS OBSERVATIONS

FEB — WAVE PERIODS AND HEIGHTS (% FREQUENCIES)

PERIOD IN SECONDS	WAVE HEIGHT (METERS) <1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	TOTAL
<6	4.5	19.2	8.5	5.8	.0	.0	.0	.0	37.9
6-7	.0	8.9	12.1	17.4	4.5	.0	.0	.0	42.9
8-9	.0	.0	3.1	4.3	4.5	2.7	.0	.0	14.7
10-11	.0	.0	.0	.0	.0	.0	.0	.0	.0
12-13	.0	.0	.0	.0	.0	.0	.0	.0	.0
>13	.0	.0	.0	.0	.0	.0	.0	.0	.0
IND	.9	2.2	1.3	.0	.0	.0	.0	.0	4.3
TOTAL	5.4	30.4	25.0	27.7	8.9	2.7	.8	.0	100.0

NUMBER OF OBS 224 — MAX WAVE HEIGHT HGT 7.0, PER 9, DIR 320, TYPE SEA, DA HR 08 12 — IND-INDETERMINATE (DIR IN DEGREES)

For each observation, the higher wave of the sea/swell group was selected for summarization; if heights were equal, the wave with the longer period was selected; if periods were also equal, the sea wave was used.

Table 7
U. S. Ocean Buoy Climatological Data
January and February 1977

JANUARY D A T A S U M M A R Y E601
AVERAGE LATITUDE 35.0N AVERAGE LONGITUDE 072.0W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	00.7	(17 15)	10.6	20.6	(10 16)	244	31
SEA TEMP (DEG C)	10.4	(31 16)	19.6	20.8	(25 21)	244	31
AIR-SEA TEMP (DEG C)	-10.0	(17 15)	-09.0	00.3	(10 18)	244	31
PRESSURE (MBAR)	0993.0	(07 15)	1012.3	1029.7	(13 15)	244	31

WIND - % FREQUENCIES, MEANS AND EXTREMES

DIR	SPEED (KNOTS) 1-	11-	22-	34-	TOTAL %	MEAN SPEED (KNOTS)	NO. OF OBS: 244
N	1.6	2.9	1.2		5.7	10.9	MAX WIND
NE			.8		.8	29.0	SPEED: 48 KNOTS
E	.4	.4	.8		1.6	21.3	DIRECTION: 190 DEG
SE	.4	1.2	.4		2.0	15.4	DAY: 07
S	.8	1.6	3.3	3.3	9.1	28.1	HOUR: 15
SW	.8	2.9	3.3	.8	7.8	22.5	
W	.4	3.3	5.3	25.8	34.8	25.1	
NW	1.6	12.7	14.3	4.1	32.8	23.3	
CALM							
TOTAL	4.9	27.0	50.0	13.1	100.0	24.8	

WAVES - % FREQUENCIES: MEAN AND EXTREME (METERS) NO. OF WAVE OBS: 169
HEIGHT (M) <1 1-1.5 2-2.5 3-3.5 4-5.5 6-7.5 8-9.5 >9.5 MEAN MAX (DA HR)
% FREQUENCY 5.9 37.5 29.0 26.6 1.2 3.1M 6.0M (08 09)

FEBRUARY D A T A S U M M A R Y E601
AVERAGE LATITUDE 35.0N AVERAGE LONGITUDE 072.0W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	03.7	(06 12)	13.5	19.5	(25 06)	220	28
SEA TEMP (DEG C)	17.7	(24 21)	18.8	19.7	(06 09)	220	28
AIR-SEA TEMP (DEG C)	-15.8	(06 12)	-05.3	01.5	(25 06)	220	28
PRESSURE (MBAR)	0995.9	(06 18)	1016.6	1028.8	(08 03)	220	28

WIND - % FREQUENCIES, MEANS AND EXTREMES

DIR	SPEED (KNOTS) 1-	11-	22-	34-	TOTAL %	MEAN SPEED (KNOTS)	NO. OF OBS: 220
N	1.8	.5	.5	.5	3.2	14.5	MAX WIND
NE		.5			.5	20.0	SPEED: 41 KNOTS
E	.5				.5	2.0	DIRECTION: 290 DEG
SE		.9	.9		1.8	21.5	DAY: 06
S	.5	2.7	7.3	3.6	15.0	17.4	HOUR: 03
SW	.5	1.8	14.1	11.4	28.2	19.8	
W	1.8	10.5	15.0	1.8	30.9	21.8	
NW	1.8	9.1	8.2	.5	19.5	19.5	
CALM	.5				.5	.0	
TOTAL	1.8	10.0	44.5	39.5	100.0	19.4	

WAVES - % FREQUENCIES: MEAN AND EXTREME (METERS) NO. OF WAVE OBS: 159
HEIGHT (M) <1 1-1.5 2-2.5 3-3.5 4-5.5 6-7.5 8-9.5 >9.5 MEAN MAX (DA HR)
% FREQUENCY 46.5 32.7 13.8 6.2 2.1M 5.0M (21 15)

JANUARY D A T A S U M M A R Y E603
AVERAGE LATITUDE 56.0N AVERAGE LONGITUDE 147.9W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	01.6	(31 03)	05.9	09.6	(24 12)	247	31
SEA TEMP (DEG C)	03.7	(31 18)	03.8	04.0	(04 21)	246	31
AIR-SEA TEMP (DEG C)	-02.2	(31 03)	00.1	02.0	(24 12)	246	31
PRESSURE (MBAR)	0964.6	(17 03)	1005.5	1017.5	(07 03)	247	31

WIND - % FREQUENCIES, MEANS AND EXTREMES

DIR	SPEED (KNOTS) 1-	11-	22-	34-	TOTAL %	MEAN SPEED (KNOTS)	NO. OF OBS: 247
N	2.8	.4			3.2	7.8	MAX WIND
NE	.4	1.2	.4		2.0	8.2	SPEED: 43 KNOTS
E	1.2	6.9	10.5	1.6	20.2	25.5	DIRECTION: 090 DEG
SE	.4	2.0	14.6	13.4	33.2	21.4	DAY: 16
S	4.5	11.7	9.3	2.0	27.5	19.4	HOUR: 06
SW	1.2	3.6	2.0	.4	7.3	19.0	
W	.4	.4	3.2	.4	4.5	14.7	
NW	.4				.4	2.0	
CALM	1.6				1.6	.0	
TOTAL	3.2	13.4	40.9	35.6	8.9	100.0	19.7

WAVES - % FREQUENCIES: MEAN AND EXTREME (METERS) NO. OF WAVE OBS: 246
HEIGHT (M) <1 1-1.5 2-2.5 3-3.5 4-5.5 6-7.5 8-9.5 >9.5 MEAN MAX (DA HR)
% FREQUENCY .8 23.2 35.7 36.6 5.7 3.7M 7.0M (16 21)

FEBRUARY D A T A S U M M A R Y E603
AVERAGE LATITUDE 56.0N AVERAGE LONGITUDE 147.9W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	00.2	(22 18)	05.5	09.7	(18 21)	205	28
SEA TEMP (DEG C)	03.6	(28 21)	03.8	04.0	(11 12)	207	28
AIR-SEA TEMP (DEG C)	-05.5	(22 18)	-00.3	01.9	(18 21)	205	28
PRESSURE (MBAR)	0960.8	(01 00)	0985.2	1011.4	(28 21)	207	28

WIND - % FREQUENCIES, MEANS AND EXTREMES

DIR	SPEED (KNOTS) 1-	11-	22-	34-	TOTAL %	MEAN SPEED (KNOTS)	NO. OF OBS: 210
N	.5	1.4	1.0	1.0	4.3	17.5	MAX WIND
NE		1.0	1.0	1.9	3.8	18.4	SPEED: 39 KNOTS
E	.5	1.4	6.2	6.7	15.2	21.1	DIRECTION: 230 DEG
SE		1.0	11.4	11.0	23.3	20.5	DAY: 22
S		1.4	14.8	5.7	21.9	17.8	HOUR: 00
SW		1.4	8.6	3.8	1.9	15.7	20.8
W	.5	1.0	9.1	1.9	.5	13.1	18.2
NW		1.0	2.9	1.9		5.7	19.8
CALM	.5					.5	.0
TOTAL	1.9	9.5	51.4	33.8	3.3	100.0	19.4

WAVES - % FREQUENCIES: MEAN AND EXTREME (METERS) NO. OF WAVE OBS: 206
HEIGHT (M) <1 1-1.5 2-2.5 3-3.5 4-5.5 6-7.5 8-9.5 >9.5 MEAN MAX (DA HR)
% FREQUENCY 22.8 36.4 39.3 1.5 3.6M 6.5M (21 21)

JANUARY D A T A S U M M A R Y E604
AVERAGE LATITUDE 26.0N AVERAGE LONGITUDE 090.0W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	10.4	(11 00)	19.4	23.9	(05 21)	212	28
DEWPOINT TEMP (DEG C)	03.9	(11 00)	15.3	23.1	(07 06)	210	28
PRESSURE (MBAR)	1006.8	(09 21)	1017.5	1026.8	(11 03)	212	28

WIND - % FREQUENCIES, MEANS AND EXTREMES

DIR	SPEED (KNOTS) 1-	11-	22-	34-	TOTAL %	MEAN SPEED (KNOTS)	NO. OF OBS: 212
N	3.8	12.3			16.0	13.6	MAX WIND
NE	.5	5.7	9.0	4.7	19.8	15.5	SPEED: 52 KNOTS
E	1.9	7.5	7.5		17.0	9.4	DIRECTION: 320 DEG
SE		7.1	6.1		13.2	10.4	DAY: 10
S		2.8	9.0		11.8	13.3	HOUR: 09
SW	.5	2.4	7.5		10.4	12.0	
W	.5	1.4	.9		2.8	9.5	
NW		2.4	3.8	2.8	9.0	17.6	
CALM							
TOTAL	3.3	33.0	56.1	7.5	100.0	12.9	

WAVES - % FREQUENCIES: MEAN AND EXTREME (METERS) NO. OF WAVE OBS: 193
HEIGHT (M) <1 1-1.5 2-2.5 3-3.5 4-5.5 6-7.5 8-9.5 >9.5 MEAN MAX (DA HR)
% FREQUENCY 23.3 49.7 22.3 4.1 .5 1.4M 4.0M (10 12)

PRECIPITATION
NO. OF DAYS WITH PRECIP: 7 NO. OF DAYS WITH REPORTS/ COMPLETE): 26 PARTIAL: 2
NO. OF OBS WITH PAST OR PRESENT PRECIP: 12 NO. OF WEATHER OBS): 12

FEBRUARY D A T A S U M M A R Y E604
AVERAGE LATITUDE 26.0N AVERAGE LONGITUDE 090.0W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	15.7	(17 00)	19.8	24.4	(24 21)	223	28
DEWPOINT TEMP (DEG C)	03.5	(17 00)	13.9	22.1	(27 06)	223	28
PRESSURE (MBAR)	1006.4	(23 21)	1019.1	1028.3	(17 15)	223	28

WIND - % FREQUENCIES, MEANS AND EXTREMES

DIR	SPEED (KNOTS) 1-	11-	22-	34-	TOTAL %	MEAN SPEED (KNOTS)	NO. OF OBS: 223
N	.9	7.2	12.6	1.8	22.4	12.6	MAX WIND
NE	.4	8.1	10.3	.9	19.7	12.3	SPEED: 28 KNOTS
E	.4	2.2	11.2	.4	14.3	14.3	DIRECTION: 150 DEG
SE		.9	9.4	1.8	12.0	16.5	DAY: 23
S		4.9	5.8	2.7	13.5	14.2	HOUR: 09
SW	.4	3.1	1.3		4.9	8.4	
W		1.8	.9		2.7	8.9	
NW	1.3		7.6	.4	9.4	13.5	
CALM							
TOTAL	3.6	29.1	59.2	8.1	100.0	13.3	

WAVES - % FREQUENCIES: MEAN AND EXTREME (METERS) NO. OF WAVE OBS: 210
HEIGHT (M) <1 1-1.5 2-2.5 3-3.5 4-5.5 6-7.5 8-9.5 >9.5 MEAN MAX (DA HR)
% FREQUENCY 20.0 46.2 30.5 3.3 1.4M 3.5M (25 09)

PRECIPITATION
NO. OF DAYS WITH PRECIP: 7 NO. OF DAYS WITH REPORTS/ COMPLETE): 28 PARTIAL: 0
NO. OF OBS WITH PAST OR PRESENT PRECIP: 13 NO. OF WEATHER OBS): 13

JANUARY D A T A S U M M A R Y E615
AVERAGE LATITUDE 32.3N AVERAGE LONGITUDE 075.3W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	03.2	(17 15)	12.3	21.2	(10 15)	244	31
SEA TEMP (DEG C)	18.7	(31 21)	20.3	22.0	(13 15)	246	31
AIR-SEA TEMP (DEG C)	-16.4	(19 18)	-08.0	00.2	(10 15)	242	31
PRESSURE (MBAR)	0993.1	(04 06)	1015.3	1030.4	(13 15)	246	31

WIND - % FREQUENCIES, MEANS AND EXTREMES

DIR	SPEED (KNOTS) 1-	11-	22-	34-	TOTAL %	MEAN SPEED (KNOTS)	NO. OF OBS: 242
N	2.5	8.3	2.1		12.8	15.1	MAX WIND
NE	.4	1.7			2.1	6.4	SPEED: 41 KNOTS
E	.4				.4	5.0	DIRECTION: 330 DEG
SE	1.2	1.2	1.7	.4	4.5	10.8	DAY: 19
S	3.3	2.5	4.5	.8	11.6	10.8	HOUR: 15
SW	.4	.4	4.5	.8	6.2	24.8	
W	.8	.8	10.3	15.3	27.7	21.8	
NW	.4	2.1	15.7	15.3	34.7	21.5	
CALM							
TOTAL	2.1	12.4	38.4	43.4	3.7	100.0	20.3

WAVES - % FREQUENCIES: MEAN AND EXTREME (METERS) NO. OF WAVE OBS: 241
HEIGHT (M) <1 1-1.5 2-2. 3-3.5 4-5.5 6-7.5 8-9.5 >9.5 MEAN MAX (DA HR)
% FREQUENCY 27.8 41.5 24.9 5.8 2.3M 5.0M (07 18)

FEBRUARY D A T A S U M M A R Y E615
AVERAGE LATITUDE 32.3N AVERAGE LONGITUDE 075.3W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	08.8	(01 03)	11.3	15.1	(04 00)	15	4
SEA TEMP (DEG C)	18.7	(03 09)	19.2	19.5	(01 21)	12	3
AIR-SEA TEMP (DEG C)	-10.3	(01 06)	-08.5	-04.5	(03 18)	11	3
PRESSURE (MBAR)	1016.6	(04 00)	1021.5	1027.5	(02 15)	16	4

WIND - % FREQUENCIES, MEANS AND EXTREMES

DIR	SPEED (KNOTS) 1-	11-	22-	34-	TOTAL %	MEAN SPEED (KNOTS)	NO. OF OBS: 13
N	7.7	15.4			23.1	12.3	MAX WIND
NE							SPEED: 23 KNOTS
E							DIRECTION: 330 DEG
SE							DAY: 01
S		7.7			7.7	16.0	HOUR: 03
SW		15.4			15.4	15.0	
W	7.7	15.4			23.1	12.0	
NW		23.1	7.7		30.8	17.0	
CALM							
TOTAL	7.7	77.0	7.7		100.0	14.4	

WAVES - % FREQUENCIES: MEAN AND EXTREME (METERS) NO. OF WAVE OBS: 11
HEIGHT (M) <1 1-1.5 2-2.5 3-3.5 4-5.5 6-7.5 8-9.5 >9.5 MEAN MAX (DA HR)
% FREQUENCY 90.9 9.1 1.5M 2.0M (01 03)

JANUARY D A T A S U M M A R Y EB16

AVERAGE LATITUDE 42.5N AVERAGE LONGITUDE 130.0W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	09.0	(26 06)	11.4	13.3	(17 08)	238	30
SEA TEMP (DEG C)	12.2	(12 15)	12.8	13.3	(02 06)	238	30
AIR-SEA TEMP (DEG C)	-03.7	(06 06)	-01.3	00.5	(17 09)	238	30
PRESSURE (MBAR)	1006.5	(02 00)	1020.3	1028.9	(24 18)	240	30

WIND - % FREQUENCIES, MEANS AND EXTREMES

DIR	SPEED (KNOTS) <4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N		2.5	7.9	.8			11.3	15.6
NE		3.8	8.8	2.1			14.6	16.0
E	.4	7.9	2.9				11.3	9.1
SE	.4	7.1	2.9				10.4	8.5
S	.4	3.8	13.8	3.8			21.7	16.0
SW	.4	3.3	5.8	.4			10.0	13.8
W	.4	1.7	6.7	1.7			10.4	16.1
NW		1.3	2.5	4.6	1.3		9.6	22.1
CALM	.8						.8	.0
TOTAL %	2.9	31.3	51.3	13.3	1.3		100.0	14.6

NO. OF OBS: 240

MAX WIND SPEED: 35 KNOTS DIRECTION: 300 DEG DAY: 03 HOUR: 00

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) NO. OF WAVE OBS: 238

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX	(DA HR)
% FREQUENCY		11.3	49.6	23.1	14.3	1.7			2.0M	7.0M	(03 00)

JANUARY D A T A S U M M A R Y EB17

AVERAGE LATITUDE 52.0N AVERAGE LONGITUDE 156.0W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	00.7	(22 06)	03.3	06.2	(04 00)	247	31
SEA TEMP (DEG C)	03.4	(31 21)	03.5	03.8	(06 06)	247	31
AIR-SEA TEMP (DEG C)	-02.7	(22 06)	-00.2	02.6	(04 00)	247	31
PRESSURE (MBAR)	0951.8	(16 06)	0992.3	1013.4	(25 21)	247	31

WIND - % FREQUENCIES, MEANS AND EXTREMES

DIR	SPEED (KNOTS) <4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N			.4	.8			1.2	15.8
NE		1.2	1.6	2.4			5.3	18.9
E		.8	8.5	7.7	1.6		18.6	21.8
SE		4.0	13.4	10.1	2.0		29.6	20.4
S	.8	4.5	13.4	4.9	.8		24.3	18.9
SW		1.2	3.6	8.1	.8		13.8	23.1
W		.8	2.8	1.2	.4		5.3	17.8
NW			.8				.8	14.5
CALM	.4						.4	.0
TOTAL %	1.2	13.0	44.9	35.2	5.7		100.0	19.7

NO. OF OBS: 247

MAX WIND SPEED: 43 KNOTS DIRECTION: 110 DEG DAY: 06 HOUR: 15

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) NO. OF WAVE OBS: 245

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX	(DA HR)
% FREQUENCY			13.5	33.1	47.3	6.1			3.9M	7.5M	(06 18)

JANUARY D A T A S U M M A R Y EB19

AVERAGE LATITUDE 51.0N AVERAGE LONGITUDE 136.0W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
PRESSURE (MBAR)	0981.7	(17 03)	1016.6	1033.0	(24 21)	247	31

WIND - % FREQUENCIES, MEANS AND EXTREMES

DIR	SPEED (KNOTS) <4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N			.4	.8			1.2	13.0
NE			.4				.4	9.0
E	.4	2.0	.4				2.8	11.5
SE		3.2	17.8	9.3	.8		31.2	18.3
S	1.6	6.5	27.1	3.1	.8		39.1	16.1
SW	.8	.8	4.9	1.6			8.1	16.0
W	1.2	2.0	.4	1.2	.4		5.3	13.9
NW		1.6	3.2	1.2			6.1	15.8
CALM	.8						.8	.0
TOTAL %	4.9	17.0	54.7	21.5	2.0		100.0	16.2

NO. OF OBS: 247

MAX WIND SPEED: 36 KNOTS DIRECTION: 280 DEG DAY: 20 HOUR: 18

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) NO. OF WAVE OBS: 241

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX	(DA HR)
% FREQUENCY		3.3	35.7	36.9	21.6	2.5			3.2M	6.5M	(15 21)

JANUARY D A T A S U M M A R Y EB35

AVERAGE LATITUDE 55.3N AVERAGE LONGITUDE 157.0W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	01.6	(22 21)	04.2	05.5	(12 03)	176	24
SEA TEMP (DEG C)	05.4	(31 21)	05.5	05.8	(17 12)	176	24
AIR-SEA TEMP (DEG C)	-03.8	(22 21)	-01.4	00.0	(24 21)	174	24
PRESSURE (MBAR)	0952.8	(16 21)	0981.7	1016.0	(08 18)	176	24

WIND - % FREQUENCIES, MEANS AND EXTREMES

DIR	SPEED (KNOTS) <4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N	.5	.6	2.3	1.2			4.7	14.5
NE	.6	.6	7.0	7.0			15.1	20.4
E		.6	18.0	15.7			34.3	20.7
SE		1.2	14.5	4.7			20.3	17.8
S		2.3	7.0	3.5			12.9	16.4
SW	1.2		1.7	4.1			7.0	17.5
W			1.7	.6			2.3	21.8
NW	.6						.6	5.0
CALM								
TOTAL %	2.3	5.8	55.2	36.8			100.0	18.8

NO. OF OBS: 172

MAX WIND SPEED: 31 KNOTS DIRECTION: 170 DEG DAY: 25 HOUR: 03

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) NO. OF WAVE OBS: 169

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX	(DA HR)
% FREQUENCY		.6	18.5	33.1	41.4	5.3			3.7M	7.0M	(25 03)

JANUARY D A T A S U M M A R Y EB41

AVERAGE LATITUDE 38.7N AVERAGE LONGITUDE 073.6W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	-09.9	(17 06)	-00.8	11.7	(07 12)	246	31
SEA TEMP (DEG C)	04.1	(28 12)	07.0	10.5	(07 09)	246	31
AIR-SEA TEMP (DEG C)	-16.5	(17 06)	-07.8	00.9	(28 21)	246	31
PRESSURE (MBAR)	0988.8	(10 18)	1013.0	1034.4	(13 15)	246	31

WIND - % FREQUENCIES, MEANS AND EXTREMES

DIR	SPEED (KNOTS) <4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N	1.2	3.3	8.6	.4			13.5	13.0
NE		2.0	.8				2.9	8.9
E	.4	.4	.4	.8			2.0	16.4
SE		.4	.8				1.6	10.5
S	.4	.4	.8	.4			2.0	13.0
SW	.8	1.6	2.0	2.9			7.3	15.9
W	.8	4.5	13.5	11.0	.8		30.6	19.5
NW	1.2	5.7	18.2	13.1	.8		40.0	18.3
CALM								
TOTAL %	4.9	18.8	46.1	28.6	1.6		100.0	17.2

NO. OF OBS: 246

MAX WIND SPEED: 36 KNOTS DIRECTION: 280 DEG DAY: 11 HOUR: 03

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) NO. OF WAVE OBS: 248

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX	(DA HR)
% FREQUENCY	11.7	34.3	34.3	16.5	3.2				1.9M	4.5M	(29 06)

% OF OBS WITH POTENTIAL SUPERSTRUCTURE ICING MODERATE:35.5% SEVERE: .4% #OBS: 245

FEBRUARY D A T A S U M M A R Y EB16

AVERAGE LATITUDE 42.5N AVERAGE LONGITUDE 130.0W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	08.8	(23 06)	11.6	14.7	(26 15)	222	28
SEA TEMP (DEG C)	10.8	(27 00)	12.0	12.6	(15 00)	222	28
AIR-SEA TEMP (DEG C)	-04.8	(23 06)	-00.3	03.5	(26 15)	222	28
PRESSURE (MBAR)	0986.9	(21 06)	1018.7	1031.6	(13 09)	222	28

WIND - % FREQUENCIES, MEANS AND EXTREMES

DIR	SPEED (KNOTS) <4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N			1.3	.9			2.2	19.6
NE	.4		.4				.9	6.5
E	1.8	.4	.4				2.7	5.2
SE	.4	3.1	8.5	2.7			14.8	14.6
S	.4	4.5	12.1	8.5	.9	.4	26.8	18.7
SW	.4	5.4	12.1	5.8			23.8	16.8
W	.9	1.8	5.8	8.1	1.8	.4	18.8	21.3
NW	.4	1.8	4.0	2.2	1.3		9.9	18.2
CALM								
TOTAL %	4.9	17.0	44.8	28.3	4.0	.9	100.0	17.6

NO. OF OBS: 223

MAX WIND SPEED: 51 KNOTS DIRECTION: 180 DEG DAY: 21 HOUR: 08

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) NO. OF WAVE OBS: 221

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX	(DA HR)
% FREQUENCY		2.7	14.9	49.8	25.3	6.3	.9		3.6M	9.0M	(21 09)

FEBRUARY D A T A S U M M A R Y EB17

AVERAGE LATITUDE 52.0N AVERAGE LONGITUDE 156.0W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	-00.3	(28 00)	02.5	04.5	(02 21)	213	28
SEA TEMP (DEG C)	02.8	(28 21)	03.5	03.5	(06 09)	214	28
AIR-SEA TEMP (DEG C)	-03.3	(07 03)	-01.0	01.3	(26 21)	213	28
PRESSURE (MBAR)	0959.4	(01 12)	0989.0	1013.3	(27 18)	214	28

WIND - % FREQUENCIES, MEANS AND EXTREMES

DIR	SPEED (KNOTS) <4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N		1.9	3.8	.5			6.1	13.6
NE		.5	3.3	2.4			6.1	20.0
E		1.4	5.3	4.2	.5		9.9	17.4
SE		1.9	6.1	5.2	.5		13.7	20.2
S		3.8	9.4	12.3	.9		26.4	21.2
SW	.5	2.8	4.7	5.8			13.3	18.0
W		1.4	7.5	7.5	.5		17.0	21.1
NW	.9	1.9	2.8	3.8			9.4	18.1
CALM								
TOTAL %	1.4	17.0	42.0	37.3	2.4		100.0	19.5

NO. OF OBS: 212

MAX WIND SPEED: 41 KNOTS DIRECTION: 120 DEG DAY: 01 HOUR: 12

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) NO. OF WAVE OBS: 214

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX	(DA HR)
% FREQUENCY			15.8	34.6	46.8	3.7			3.8M	6.5M	(14 00)

FEBRUARY D A T A S U M M A R Y EB19

AVERAGE LATITUDE 51.0N AVERAGE LONGITUDE 136.0W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
PRESSURE (MBAR)	0964.9	(20 18)	1006.7	1022.1	(13 12)	223	28

WIND - % FREQUENCIES, MEANS AND EXTREMES

DIR	SPEED (KNOTS) <4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N				.9	.4		1.8	21.0
NE					.9		.9	35.5
E			1.3	2.2	.9		4.5	24.5
SE			1.3	3.1	4.0		21.5	25.5
S			1.8	13.0	13.5	2.7	.4	31.4	23.2
SW			1.3	6.7	8.5	3.1		19.7	25.3
W		.4	.4	5.8	9.4	2.7		18.8	23.6
NW		.4		3.6	1.3			5.4	16.3
CALM									
TOTAL %		1.3	6.3	32.3	44.8	14.8	.4	100.0	23.8

NO. OF OBS: 223

MAX WIND SPEED: 49 KNOTS DIRECTION: 160 DEG DAY: 20 HOUR: 21

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) NO. OF WAVE OBS: 220

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX	(DA HR)
% FREQUENCY		.5	5.0	28.2	53.2	10.0	3.2		4.4M	8.5M	(21 06)

FEBRUARY D A T A S U M M A R Y EB35

AVERAGE LATITUDE 55.3N AVERAGE LONGITUDE 157.0W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	-00.1	(24 18)	03.4	05.5	(01 15)	205	27
SEA TEMP (DEG C)	05.0	(28 18)	05.3	05.7	(19 00)	205	27
AIR-SEA TEMP (DEG C)	-05.2	(24 18)	-02.0	00.1	(01 15)	205	27
PRESSURE (MBAR)	0960.3	(19 03)	0988.2	1008.5	(23 06)	206	27

WIND - % FREQUENCIES, MEANS AND EXTREMES

DIR	SPEED (KNOTS) <4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N		.5	3.0	.5			4.0	15.9
NE			1.5	4.5			5.9	22.8
E		3.0	9.9	5.9			18.8	18.2
SE	.5	5.9	11.4	6.4			21.8	17.8
S	.5	3.0	13.9	6.9			24.3	17.6
SW		.5	2.5	.5			3.5	15.6
W	1.0	3.5	4.5	2.5			11.4	14.5
NW	.5	2.0	5.4	2.5			10.4	16.5
CALM								
TOTAL %	2.5	15.8	52.0	29.7			100.0	17.4

NO. OF OBS: 202

MAX WIND SPEED: 31 KNOTS DIRECTION: 120 DEG DAY: 26 HOUR: 06

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) NO. OF WAVE OBS: 190

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX	(DA HR)
% FREQUENCY		1.1	20.9	35.3	34.7				3.4M	5.5M	(15 18)

FEBRUARY D A T A S U M M A R Y EB41

AVERAGE LATITUDE 38.7N AVERAGE LONGITUDE 073.6W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	-07.7	(06 12)	05.3	12.7	(28 00)	221	28
SEA TEMP (DEG C)	02.6	(15 15)	06.2	09.2	(17 00)	221	28
AIR-SEA TEMP (DEG C)	-13.5	(17 12)	-00.9	06.2	(25 00)	221	28
PRESSURE (MBAR)	0994.5	(05 18)	1015.0	1031.4	(08 15)	220	28

WIND - % FREQUENCIES, MEANS AND EXTREMES

DIR	SPEED (KNOTS) <4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N			1.8				1.8	16.3
NE		1.8					1.8	5.5
E	.5	2.7	.5				3.6	6.1
SE		2.3	2.3				4.5	11.3
S	.5	3.6	5.9				10.0	11.0
SW		5.9	8.6	6.4			20.9	15.7
W	.9	8.2	12.3	10.0	.5		31.8	16.3
NW	.9	5.0	14.5	5.0			25.5	16.2
CALM								
TOTAL %	2.7	29.5	45.8	21.4	.5		100.0	14.8

NO. OF OBS: 220

MAX WIND SPEED: 34 KNOTS DIRECTION: 280 DEG DAY: 06 HOUR: 00

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) NO. OF WAVE OBS: 220

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX	(DA HR)
% FREQUENCY	23.6	44.5	23.2	6.8	1.8				1.4M	4.0M	(06 15)

% OF OBS WITH POTENTIAL SUPERSTRUCTURE ICING MODERATE:15.5% SEVERE: NONE #OBS: 220

JANUARY — DATA SUMMARY — E870

AVERAGE LATITUDE 59.5N — AVERAGE LONGITUDE 142.3W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	03.2	(02 21)	05.1	07.2	(17 06)	234	31
SEA TEMP (DEG C)	06.2	(12 06)	06.7	07.1	(15 03)	234	31
AIR-SEA TEMP (DEG C)	-03.8	(02 21)	-01.6	00.5	(14 18)	234	31
PRESSURE (MBAR)	0975.1	(17 09)	1012.2	1026.8	(07 09)	234	31

WIND - % FREQUENCIES, MEANS AND EXTREMES

SPEED (KNOTS) DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N	.9	.4					1.3	4.1
NE	.9	.9	1.7				3.4	9.8
E	.4	6.4	22.2	28.2	2.6		59.8	21.7
SE		1.7	11.1	5.6			18.4	18.4
S		2.1	3.8	3.0			9.0	17.7
SW	.4	.4	1.7		.4		3.0	17.0
W	.4	.9	.9				2.1	10.0
NW		1.7	.4				2.1	10.6
CALM	.9						.9	.0
TOTAL %	3.8	14.5	41.9	36.8	3.0		100.0	19.3

NO. OF OBS: 234

MAX WIND SPEED: 40 KNOTS DIRECTION: 100 DEG DAY: 16 HOUR: 15

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) — NO. OF WAVE OBS: 214

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX	(DA HR)
% FREQUENCY		7.9	32.7	29.0	23.4	6.5		.5	3.5M	10.0M	(17 06)

FEBRUARY — DATA SUMMARY — E870

AVERAGE LATITUDE 59.5N — AVERAGE LONGITUDE 142.3W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	01.8	(25 00)	05.1	08.4	(04 09)	215	28
SEA TEMP (DEG C)	05.8	(14 15)	06.6	08.8	(04 09)	214	28
AIR-SEA TEMP (DEG C)	-04.6	(28 21)	-01.4	01.7	(04 09)	214	28
PRESSURE (MBAR)	0978.6	(21 21)	1000.9	1013.9	(03 03)	215	28

WIND - % FREQUENCIES, MEANS AND EXTREMES

SPEED (KNOTS) DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N		.9					.9	6.0
NE		.9	1.9				2.8	11.8
E	.5	.9	11.3	36.3	2.8		51.9	24.6
SE		1.4	9.4	9.0			19.8	21.4
S	.5	2.8	5.7	.9			9.8	19.4
SW		1.9	2.4	.9			5.2	19.6
W		.9	5.2	.5			6.6	19.8
NW	.5	1.9					2.4	8.2
CALM	.5						.5	.0
TOTAL %	1.9	11.8	35.8	47.6	2.8		100.0	20.7

NO. OF OBS: 212

MAX WIND SPEED: 36 KNOTS DIRECTION: 100 DEG DAY: 21 HOUR: 21

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) — NO. OF WAVE OBS: 182

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX	(DA HR)
% FREQUENCY		1.6	23.1	37.4	28.1	8.8			3.7M	7.5M	(21 12)

JANUARY — DATA SUMMARY — E871

AVERAGE LATITUDE 26.0N — AVERAGE LONGITUDE 093.5W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	09.3	(10 12)	18.0	23.0	(05 21)	245	31
SEA TEMP (DEG C)	19.7	(31 21)	21.3	22.6	(08 21)	245	31
AIR-SEA TEMP (DEG C)	-12.0	(10 12)	-03.2	01.2	(14 03)	245	31
PRESSURE (MBAR)	1005.6	(09 12)	1018.7	1028.0	(19 18)	245	31

WIND - % FREQUENCIES, MEANS AND EXTREMES

SPEED (KNOTS) DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N		5.3	18.4	2.9			26.5	15.3
NE		3.3	5.7	1.6			10.6	15.2
E	.4	3.7	9.8	4.1			18.0	15.3
SE		2.4	12.2	.4			15.1	14.4
S		1.6	.8				9.4	12.7
SW	.4	2.9	4.9				8.2	11.0
W	.8	1.6	.4	.8			3.7	11.4
NW		2.0	3.7	2.9			8.6	17.4
CALM								
TOTAL %	1.6	22.9	62.9	12.7			100.0	14.6

NO. OF OBS: 245

MAX WIND SPEED: 33 KNOTS DIRECTION: 320 DEG DAY: 10 HOUR: 03

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) — NO. OF WAVE OBS: 240

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX	(DA HR)
% FREQUENCY	12.9	55.0	20.8	9.6	1.7				1.6M	5.0M	(10 12)

FEBRUARY — DATA SUMMARY — E871

AVERAGE LATITUDE 26.0N — AVERAGE LONGITUDE 093.5W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	14.3	(16 12)	18.7	22.7	(26 15)	220	28
SEA TEMP (DEG C)	19.9	(01 00)	21.4	22.7	(14 21)	220	28
AIR-SEA TEMP (DEG C)	-06.9	(16 12)	-02.7	01.2	(26 15)	220	28
PRESSURE (MBAR)	1006.5	(23 21)	1019.3	1028.4	(16 15)	220	28

WIND - % FREQUENCIES, MEANS AND EXTREMES

SPEED (KNOTS) DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N	1.8	4.1	15.5	2.7			24.2	14.0
NE		3.7	7.8	3.7			15.1	15.8
E	.9	3.7	8.2	2.7			15.5	15.2
SE	.5	.9	13.2	2.3			16.9	17.5
S	.5	3.7	10.0	1.4			15.5	14.0
SW		.9					.9	9.0
W	.5	.5	1.4				2.3	9.4
NW	1.4	1.4	5.9	.9			9.6	12.8
CALM								
TOTAL %	5.5	18.7	62.1	13.7			100.0	14.7

NO. OF OBS: 219

MAX WIND SPEED: 27 KNOTS DIRECTION: 140 DEG DAY: 26 HOUR: 09

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) — NO. OF WAVE OBS: 221

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX	(DA HR)
% FREQUENCY	12.7	47.5	28.9	9.5	.5				1.6M	4.0M	(25 21)

JANUARY — DATA SUMMARY — E821

AVERAGE LATITUDE 46.0N — AVERAGE LONGITUDE 131.0W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	05.8	(02 12)	09.0	11.2	(01 09)	10	2
SEA TEMP (DEG C)	11.4	(02 12)	11.5	11.6	(01 21)	10	2
AIR-SEA TEMP (DEG C)	-05.6	(02 12)	-02.6	-01.0	(01 09)	10	2
PRESSURE (MBAR)	0998.1	(01 15)	1001.0	1004.7	(01 09)	10	2

WIND - % FREQUENCIES, MEANS AND EXTREMES

SPEED (KNOTS) DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N								
NE								
E								
SE		10.0					10.0	16.0
S		10.0					10.0	12.0
SW								
W				40.0	30.0		70.0	32.7
NW				10.0			10.0	32.0
CALM								
TOTAL %		20.0	50.0	30.0			100.0	28.9

NO. OF OBS: 10

MAX WIND SPEED: 40 KNOTS DIRECTION: 280 DEG DAY: 02 HOUR: 12

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) — NO. OF WAVE OBS: 10

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX	(DA HR)
% FREQUENCY		30.0	10.0	10.0	30.0	20.0			3.9M	7.0M	(02 12)

FEBRUARY — DATA SUMMARY — E845

AVERAGE LATITUDE 59.0N — AVERAGE LONGITUDE 142.0W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	01.4	(25 06)	04.5	08.3	(20 21)	126	17
SEA TEMP (DEG C)	05.6	(28 12)	06.4	08.7	(28 21)	126	17
AIR-SEA TEMP (DEG C)	-05.2	(25 06)	-01.9	01.7	(20 21)	126	17
PRESSURE (MBAR)	0978.8	(21 21)	1000.5	1015.9	(28 21)	125	17

WIND - % FREQUENCIES, MEANS AND EXTREMES

SPEED (KNOTS) DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N	.8	3.2					4.0	8.0
NE	.8		4.8	.8			6.5	15.6
E	1.6	4.8	40.5	25.4			72.2	18.5
SE	.8	2.4	4.0	.8			7.9	12.1
S			2.4				2.4	12.7
SW								
W		4.0	2.4				6.3	9.8
NW		.8					.8	8.0
CALM								
TOTAL %	4.0	15.1	54.0	27.0			100.0	16.4

NO. OF OBS: 126

MAX WIND SPEED: 31 KNOTS DIRECTION: 080 DEG DAY: 18 HOUR: 18

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) — NO. OF WAVE OBS: 116

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX	(DA HR)
% FREQUENCY		3.4	38.8	36.2	17.2	4.3			3.1M	7.0M	(19 09)

JANUARY — DATA SUMMARY — E844

AVERAGE LATITUDE 26.0N — AVERAGE LONGITUDE 086.0W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	16.7	(08 12)	21.2	25.2	(03 09)	67	10
SEA TEMP (DEG C)	24.8	(03 09)	25.6	26.4	(08 21)	59	9
AIR-SEA TEMP (DEG C)	-09.5	(08 12)	-04.7	00.5	(05 09)	54	9
PRESSURE (MBAR)	1004.4	(09 21)	1015.0	1019.3	(02 15)	50	10

WIND - % FREQUENCIES, MEANS AND EXTREMES

SPEED (KNOTS) DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N		1.4	6.9				8.3	13.5
NE		6.3	15.3				23.6	12.8
E		15.3	9.7	2.8			27.8	12.1
SE		1.4	5.6				6.9	11.8
S	2.8	1.4	8.3	1.4			13.9	14.0
SW		2.8	4.2	1.4			8.3	15.7
W	1.4			2.8			4.2	18.0
NW	1.4		1.4	4.2			6.9	18.8
CALM								
TOTAL %	5.6	30.6	51.4	12.5			100.0	13.6

NO. OF OBS: 72

MAX WIND SPEED: 27 KNOTS DIRECTION: 320 DEG DAY: 10 HOUR: 09

JANUARY — DATA SUMMARY — E861

AVERAGE LATITUDE 28.5N — AVERAGE LONGITUDE 090.9W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	00.5	(19 18)	10.7	22.8	(09 15)	213	31

WIND - % FREQUENCIES, MEANS AND EXTREMES

SPEED (KNOTS) DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N		4.2	13.2	5.2	.9		23.6	17.3
NE	.5	5.2	12.7	6.1	.5		25.0	17.6
E	.5	3.8	9.8	4.2	.9		19.5	17.0
SE		2.8	4.2				7.1	13.5
S		3.8	3.8	1.4			9.0	13.4
SW	.5	.5	1.9	.9	.5		4.2	18.2
W	.9	.9	1.9				3.8	8.6
NW	.9	2.4	3.3	.5	.5		7.5	12.6
CALM	.5						.5	.0
TOTAL %	3.8	23.6	50.9	18.4	3.3		100.0	16.0

NO. OF OBS: 212

MAX WIND SPEED: 42 KNOTS DIRECTION: 220 DEG DAY: 20 HOUR: 09

Table 8
Selected Gale and Wave Observations, North Atlantic
January and February 1977

Vessel	Nationality	Date	Position of Ship Lat. deg.	Position of Ship Long. deg.	Time GMT	Wind Dir. 10°	Wind Speed kt.	Visibility n. mi.	Present Weather code	Pressure mb.	Temperature °C Air	Temperature °C Sea	Sea Waves? Period sec.	Sea Waves? Height ft.	Swell Waves Dir. 10°	Swell Waves Period sec.	Swell Waves Height ft.
NORTH ATLANTIC OCEAN		JAN.															
AMER LEADER	AMERICAN	1	37.7 N	56.3 W	06	21	42	5 NM	02	999.2	19.4	19.7	8	16.5	24	12	19.5
CHASTINE MAERSK	DANISH	2	42.5 N	32.9 W	18	20	42	2 NM	07	1010.5	17.1	16.5	8	11.5	24	10	24.5
CHESHIRE	BRITISH	2	37.4 N	70.2 W	06	31	45	5 NM	90	1008.0	7.7		6	18	31	10	18
ADM W M CALLAGHAN	AMERICAN	2	57.6 N	23.5 W	18	19	50	5 NM	07	997.5	11.7	9.4	8	24.5			
AMER CHALLENGER	AMERICAN	2	58.3 N	17.8 W	18	18	42	5 NM	60	1010.1	10.0	8.9	6	13	23	11	16.5
ADM W M CALLAGHAN	AMERICAN	3	57.5 N	25.3 W	00	20	50	5 NM	07	998.9	12.2	7.7	9	29.5			
AMER CHALLENGER	AMERICAN	3	57.4 N	23.6 W	12	18	42	5 NM	07	999.0	10.0	10.0	6	13	23	10	16.5
CHASTINE MAERSK	DANISH	4	43.3 N	38.3 W	00	27	45	5 NM	01	1005.5	12.5	14.0	7	16.5	26	9	29.5
EXXON HUNTINGTON	AMERICAN	4	32.7 N	77.8 W	06	36	M 42	2 NM	15	1006.0	15.7	22.3	3	10			
EXPORT AMBASSADOR	AMERICAN	5	37.4 N	54.3 W	18	17	45	2 NM	81	1009.8	17.7	19.4	9	8	17	12	19.5
DALLAS	AMERICAN	5	39.4 N	64.1 W	12	35	50	2 NM	02	998.9	19.0	16.7	8	8			
CHASTINE MAERSK	DANISH	6	42.7 N	53.5 W	00	22	45	2 NM	82	998.0	13.0	10.0	10	37.5	16	12	32.5
WORTH	AMERICAN	6	38.2 N	62.7 W	18	04	45	10 NM	15	1005.8	12.5	18.3			04	< 6	14.5
EXPORT AMBASSADOR	AMERICAN	7	39.3 N	69.9 W	18	30	70	< 30 YD	82	976.6	6.7	13.6	4	6.5			
TEXACO MISSISSIPPI	AMERICAN	7	37.0 N	74.7 W	18	30	44	5 NM	01	1001.0	7.9	11.2			30	< 6	6.5
TRINITY	AMERICAN	8	39.7 N	67.6 W	12	29	42	2 NM	07	997.2	3.8	13.4	3	8	28	7	29.5
DALLAS	AMERICAN	8	40.4 N	64.3 W	18	32	50	2 NM	07	993.6	11.9	16.7	7	16.5	28	9	10
BALTIMORE TRADER	AMERICAN	10	37.1 N	72.7 W	15	14	48	2 NM	51	1000.0	18.9	22.2	7	8	21	>13	29.5
ZIM NEW YORK	GERMAN	10	35.1 N	73.7 W	21	23	47	10 NM	01	999.8	17.2	22.8	9	19.5	XX	X	23
ESSO CORAL GABLES	LIBERIAN	10	37.5 N	70.6 W	21	23	50	2 NM	91	998.0	16.0	23.0	9	24.5			
OVERSEAS NATALIE	AMERICAN	10	36.2 N	71.6 W	18	18	48	5 NM	21	992.6	16.6	21.7	4	23			
SEALAND GALLOWAY	AMERICAN	11	40.8 N	63.3 W	06	18	60	2 NM	62	994.9	16.2	13.5	8	29.5	18	12	29.5
BALTIMORE TRADER	AMERICAN	11	40.9 N	69.0 W	12	28	50	2 NM	07	1005.0	= 3.3	5.6	5	6.5	28	7	24.5
ZIM NEW YORK	GERMAN	11	34.3 N	73.7 W	00	25	45	10 NM	00	1014.6	15.2	19.4					
ESSO CORAL GABLES	LIBERIAN	11	37.0 N	69.8 W	03	27	45	2 NM	03	1002.0	11.0	20.0	8	24.5			
ATLANTICA LIVORNO	GERMAN	11	42.5 N	62.8 W	06	16	48	2 NM	63	994.0	13.0		6	13	14	12	19.5
DALLAS	AMERICAN	11	41.1 N	64.2 W	06	21	55	5 NM	01	995.8	17.9	15.6					
OVERSEAS NATALIE	AMERICAN	11	35.2 N	71.6 W	06	27	48	5 NM	01	1005.8	10.6	25.0	6	23			
DALLAS	AMERICAN	12	40.5 N	64.7 W	00	27	60	2 NM	07	1011.0	13.5	15.6					
SEALAND GALLOWAY	AMERICAN	12	41.3 N	53.6 W	00	19	45	5 NM	62	1010.2	16.7	14.0	6	19.5	18	12	19.5
STAGHOUND	AMERICAN	13	49.2 N	14.1 W	06	29	45	5 NM	18	983.0	7.2	11.2	4	6.5	29	8	10
DOCTOR LYKES	AMERICAN	13	49.7 N	04.1 W	18	27	M 60	2 NM	07	975.0	9.8	9.4	XX	24.5	24	7	32.5
EXPORT PATRIOT	AMERICAN	13	42.2 N	53.7 W	18	33	42	30 YD	74	991.2	2.2	15.5	5	10	02	10	16.5
IRISH STAR	AMERICAN	13	38.5 N	50.5 W	18	27	45	2 NM	16	988.5	9.0	11.0	9	24.5	27	12	13
DOCTOR LYKES	AMERICAN	14	49.0 N	07.7 W	12	31	M 50	> 25 NM	16	1001.0	6.1	10.0	7	13	31	8	16.5
EXPORT PATRIOT	AMERICAN	14	42.3 N	50.9 W	06	30	50	30 YD	86	990.0	4.5	6.7	8	11.5	33	9	14.5
IRISH STAR	IRISH	15	37.7 N	57.9 W	18	17	45	1 NM	65	998.5	13.0	13.0	8	16.5	22	13	19.5
AUSTRAL PILGRIM	AMERICAN	15	35.6 N	69.6 W	06	18	43	5 NM	18	1005.4	18.0	19.5	8	23			
DOCTOR LYKES	AMERICAN	16	46.6 N	71.8 W	00	16	50	5 NM	80	1004.0	12.2	10.6	3	10	16	8	10
SEALAND CONSUMER	AMERICAN	16	37.6 N	39.0 W	18	22	50	5 NM	62	1005.8	18.0	15.0	5	10	23	< 6	18
ROBERT E LEE	AMERICAN	17	36.3 N	40.7 W	00	24	M 50	5 NM	02	1010.5	13.0	14.4			24	8	16.5
RALPH B JOHNSON	LIBERIAN	17	33.5 N	62.3 W	18	26	M 41	10 NM	07	1003.5	20.0	22.0		8	26	X	13
DOCTOR LYKES	AMERICAN	17	44.6 N	29.7 W	00	18	55	10 NM	01	996.0	14.4	12.3	5	11.5	23	11	14.5
IRISH STAR	IRISH	17	37.1 N	66.0 W	18	28	45	5 NM	88	1000.5	4.5	9.0	10	26	30	12	16.5
EVERGREEN	AMERICAN	17	38.2 N	62.5 W	12	28	M 42	2 NM	03	994.2	12.2	20.0	3	8	23	< 6	10
NORMACCAPE	AMERICAN	18	35.2 N	67.0 W	00	29	41	5 NM	02	1007.5	8.4	21.1	4	14.5	29	6	19.5
RALPH B JOHNSON	LIBERIAN	18	33.8 N	63.7 W	00	26	M 41	5 NM	07	1006.0	13.0	22.0					
IRISH STAR	IRISH	18	37.1 N	66.7 W	00	28	45	5 NM	88	1002.5	3.5	9.0	8	19.5	30	13	16.5
SUGAR ISLANDER	AMERICAN	18	25.6 N	86.5 W	18	29	45	5 NM	25	1013.0	17.3		4	8			
SUGAR ISLANDER	AMERICAN	19	25.7 N	88.0 W	06	29	45	10 NM	02	1017.8	12.3		4	13	29	6	14.5
SAN MARCOS	AMERICAN	19	29.0 N	78.5 W	18	30	55	5 NM	23	1012.5	6.5	22.2	12	29.5			
AMER LEADER	AMERICAN	20	45.3 N	59.2 W	18	28	42	5 NM	02	984.3	- 7.5	0.0	5	10			
MORMACLYNX	AMERICAN	20	30.2 N	63.0 W	12	27	45	10 NM	03	1012.0	15.8	20.0			27	7	8
MARSHFIELD	AMERICAN	20	30.5 N	59.3 W	06	23	55	2 NM	58	1000.7	20.6	21.6	6	8	23	6	16.5
RED JACKET	AMERICAN	20	39.9 N	47.4 W	18	20	50	10 NM	02	987.0	20.0	16.2	4	10	27	10	11.5
DOCTOR LYKES	AMERICAN	20	34.8 N	53.9 W	12	23	M 75	2 NM	03	994.0	17.2	18.9	6	13	27	11	16.5
CHEVRON PERTH	LIBERIAN	20	[illegible]	[illegible]	06	23	M 60	5 NM	16	[illegible]	13.5	21.2	5	10			
ECUADORIAN REFFER	DANISH	20	[illegible]	[illegible]	16	27	47	2 NM	91	999.0	1.9	4.5	9	19.5			
JEFF DAVIS	AMERICAN	20	34.9 N	20.1 W	18	25	48	5 NM	01	1005.8	18.7	17.8	3	16.5	25	7	26
FROSTFJORD	NORWEGIAN	20	36.6 N	46.1 W	18	20	M 45	2 NM	64	1004.0	20.0						
EXPORT DIPLOMAT	AMERICAN	20	42.8 N	52.0 W	18	27	60	2 NM	51	980.0	5.0	5.5	2	6.5	27	8	24.5
SAN MARCOS	AMERICAN	20	26.2 N	79.6 W	00	30	45	10 NM	03	1017.3	9.0	22.2	10	24.5			
SEALAND PRODUCER	AMERICAN	20	35.3 N	46.7 W	18	24	M 45	2 NM	18	1006.4	17.7	16.2	6	8	23	9	13
SEALAND CONSUMER	AMERICAN	20	29.8 N	61.5 W	06	28	55	5 NM	01	1002.5	18.3	19.4					
EXPORT DIPLOMAT	AMERICAN	21	43.5 N	55.0 W	18	27	60	5 NM	02	992.0	2.7	7.8	6	36			
AMER COURIER	AMERICAN	21	41.6 N	60.5 W	00	29	45	5 NM	02	996.2	7.2	18.9	5	14.5			
MARSHFIELD	AMERICAN	21	29.7 N	63.3 W	12	27	45	5 NM	02	1010.0	17.7	22.2	6	6.5	27	8	14.5
EXPORT DIPLOMAT	AMERICAN	22	43.4 N	56.0 W	00	28	45	10 NM	01	993.6	2.3	5.5	6	32.5			
EVERGREEN	AMERICAN	22	32.1 N	66.7 W	12	29	M 44	5 NM	03	1009.0	14.3	20.0	10	11.5			
EXXON HUNTINGTON	AMERICAN	22	36.8 N	74.6 W	18	34	M 45	5 NM	05	1015.0	5.0	16.7	6	11.5			
DELAWARE SUN	AMERICAN	22	31.0 N	73.3 W	18	30	45	5 NM	16	1015.9	11.0	18.3	11	14.5			
EAGLE CHARGER	AMERICAN	23	30.3 N	53.5 W	18	27	50	5 NM	07	1009.5	18.8	19.4	7	19.5	27	8	23
EXPORT BUILDER	AMERICAN	23	38.7 N	46.2 W	12	25	45	5 NM	16	986.8	17.2	18.9	XX	10	24	8	49
JEFF DAVIS	AMERICAN	23	31.2 N	60.5 W	06	26	48	5 NM	23	1004.7	13.3	17.8	2	13	27	< 6	19.5
ARCO ANCHORAGE	AMERICAN	23	31.2 N	59.0 W	12	27	46	5 NM	02	1006.1	14.0	17.3	8	23			
MARSHFIELD	AMERICAN	23	29.8 N	69.0 W	00	28	45	10 NM	02	1013.5	14.0	21.8	6	6.5	28	8	18
EAGLE CHARGER	AMERICAN	24	30.1 N	54.0 W	00	27	50	5 NM	07	1008.5	18.8	19.4	7	19.5	27	8	23
PENN SUN	AMERICAN	25	24.7 N	84.2 W	12	36	50	30 YD	82	1014.2	20.0	21.1	3	5	27	6	5
EXPORT PATRIOT	AMERICAN	26	49.3 N	16.6 W	18	23	45	10 NM	02	977.3	8.8	11.2	4	5	23	9	29.5
OCEANGRA	BRAZILIAN	26	46.2 N	20.7 W	12	25	M 43	5 NM	03	994.0	10.0	12.0	11	10			
SEALAND GALLOWAY	AMERICAN	26	35.8 N	59.9 W	06	18	50	10 NM	18	1005.1	17.2	16.2	7	14.5			
SEALAND MARKET	AMERICAN	26	42.0 N	57.6 W	18	27	45	2 NM	64	990.5	11.7	9.5	4	10	18	>13	49
ADM W M CALLAGHAN	AMERICAN	26	45.7 N	57.0 W	18	14	45	1 NM	59	986.5	4.4	2.0	6	16.5			
LASH ITALIA	AMERICAN	26	37.8 N	64.1 W	06	17	50	2 NM	21	993.2	13.6	15.0	8	16.5			
MOBIL MERIDIAN	AMERICAN	26	31.0 N	56.6 W	18	20	50	5 NM	65	1011.9	18.8	20.0	6	6.5	23	>13	14.5
SAM RATULANGIE	INDONESIAN	29	36.6 N	20.8 W	18	32	M 48	5 NM	07	1014.0	15.0	17.0	5	18			

Vessel	Nationality	Date	Position of Ship		Time GMT	Wind			Visibility n. mi.	Present Weather code	Pressure mb.	Temperature °C		Sea Waves†		Swell Waves		
			Lat. deg.	Long. deg.		Dir. 10°		Speed kt.				Air	Sea	Period sec.	Height ft.	Dir. 10°	Period sec.	Height ft.
NORTH ATLANTIC OCEAN		JAN.																
OCEAN STATION VESSELS																		
ATLANTIC M																		
INGHAM	AMERICAN	1	38.0 N	71.0 W	18	30	M	50	200 YD	86	1002.1	2.1	14.2	9	19.5			
INGHAM	AMERICAN	7	38.0 N	71.0 W	21	31	M	46	2 NM	80	994.4	7.2	17.0	8	19.5			
INGHAM	AMERICAN	8	38.0 N	71.0 W	03	30	M	57	5 NM	26	1001.8	3.8	15.6	9	26			
INGHAM	AMERICAN	10	38.0 N	71.0 W	15	18	M	53	1 NM	21	1002.2	17.8	14.7	10	23			
INGHAM	AMERICAN	11	37.7 N	70.8 W	00	25	M	52	5 NM	07	998.3	18.0	15.8	12	24.5			
TANEY	AMERICAN	17	38.0 N	71.0 W	06	30	M	48	2 NM	71	1004.7	0.3	14.8	6	11.5			
TANEY	AMERICAN	27	38.0 N	71.0 W	12	25	M	46	5 NM	15	1002.7	13.2	12.0	9	11.5			
TANEY	AMERICAN	29	38.0 N	71.0 W	09	31	M	46	.25 NM	45	1002.0	0.3	15.5	7	11.5			
GREAT LAKES VESSELS																		
PHILIP R CLARKE	AMERICAN	18	47.4 N	86.5 W	06	36	M	45	5 NM	70		- 6.0	3.0	5	8			
NORTH ATLANTIC OCEAN		FEB.																
SAM RATULANGIE	INDONESIAN	1	38.1 N	40.5 W	18	23	M	44	5 NM	02	1010.0	18.3	18.5	7	32.5			
SEALAND PRODUCER	AMERICAN	1	34.6 N	47.9 W	18	24	M	45	10 NM	03	1009.0	20.0	15.0	5	10	27	8	13
TILLIE LYKES	AMERICAN	1	49.0 N	11.0 W	18	21		45	5 NM	02	1003.2	8.9	10.0	4	8			
SEALAND PRODUCER	AMERICAN	2	33.4 N	49.7 W	00	24	M	45	5 NM	02	1011.0	21.1	16.7	5	10	27	8	13
SAM RATULANGIE	INDONESIAN	2	37.5 N	45.6 W	18	23	M	44	2 NM	02	1001.0	18.9	19.0	7	32.5			
SAM RATULANGIE	INDONESIAN	3	37.6 N	47.6 W	06	28	M	52	2 NM	02	1000.5	13.7	19.0	9	36			
NOPAL SEL	NORWEGIAN	3	43.7 N	44.7 W	18	28	M	55	1 NM	86	995.0	2.0	16.0	XX	10	30	10	19.5
TILLIE LYKES	AMERICAN	4	49.0 N	37.0 W	12	27		75	1 NM		973.6	5.0	12.7	7	29.5			
SAM RATULANGIE	INDONESIAN	4	38.1 N	53.5 W	18	22	M	44	5 NM	02	1004.0	17.0	19.0	7	32.5			
AMER LEGACY	AMERICAN	4	50.8 N	31.3 W	18	23		55	5 NM	27	967.5	8.6	11.2	4	18	23	13	32.5
LIGHTNING	AMERICAN	4	48.0 N	47.6 W	00	28		45	5 NM	02	987.0	- 1.7	2.3	4	11.5	29	8	29.5
NOPAL SEL	NORWEGIAN	4	44.4 N	38.4 W	12	26	M	48	10 NM	03	998.0	9.0		8	10	29	10	16.5
SAM RATULANGIE	INDONESIAN	5	38.0 N	54.4 W	00	24	M	42	2 NM	07	1002.0	17.7	19.0	8	32.5			
AMER LEADER	AMERICAN	5	43.1 N	38.7 W	06	22		42	10 NM	02	1000.0	16.2	15.6	5	5	22	10	23
AMER LEGACY	AMERICAN	5	50.9 N	32.6 W	00	32		46	5 NM	25	971.5	7.2	10.0	4	14.5	23	13	31
SEALAND RESOURCE	AMERICAN	6	37.2 N	71.7 W	12	31		45	.5 NM	72	1012.7	- 2.0	18.4	15	23			
EXXON FLORENCE	AMERICAN	6	38.3 N	74.5 W	12	33		47	10 NM	03	1016.2	- 5.5	10.6	5	8			
EXXON CHESTER	AMERICAN	6	38.2 N	74.5 W	06	29	M	46	10 NM	02	1012.5	- 1.0	10.5	5	13	27	13	19.5
COMET	AMERICAN	6	37.6 N	73.9 W	06	29		50	5 NM	02	1008.5	- 3.9	12.8	10	11.5	27	>13	19.5
EXPORT CHALLENGER	AMERICAN	6	39.5 N	54.5 W	12	23		58	2 NM	07	986.8	16.7	17.2	3	14.5	23	6	29.5
SAM RATULANGIE	INDONESIAN	6	39.0 N	61.9 W	12	27		55	1 NM	07	989.0	14.5	20.0	8	36			
AMER LEGACY	AMERICAN	6	49.1 N	39.7 W	00	27		50	5 NM	27	991.8	3.4	11.1	5	14.5	27	>13	32.5
NORMACSUN	AMERICAN	6	34.4 N	68.6 W	00	27		45	5 NM	01	997.4	15.5	17.7	7	18			
TILLIE LYKES	AMERICAN	7	45.4 N	57.0 W	06	29		45	5 NM	02	998.6	- 1.7	- 0.5	7	13			
EXPORT CHALLENGER	AMERICAN	7	39.3 N	54.8 W	00	28		45	5 NM	13	996.0	11.1	17.2	XX	11.5	27	7	29.5
SAM RATULANGIE	INDONESIAN	7	39.1 N	64.5 W	06	27	M	48	1 NM		1009.0	5.8	15.0	7	32.5			
SEALAND MARKET	AMERICAN	8	33.7 N	37.8 W	12	25		47	2 NM	25	1015.9	18.3	15.6	5	8	27	>13	32.5
SEALAND MARKET	AMERICAN	9	34.3 N	43.0 W	00	27		40	10 NM	01	1016.6	17.8	18.3	4	8	29	12	39
FALSTRIA	DANISH	10	43.1 N	23.8 W	06	26	M	50	10 NM	03	1004.0	12.8		20	36			
STAGHOUND	AMERICAN	11	45.5 N	27.0 W	06	28		45	2 NM	63	1002.8	8.8	12.8	5	10	28	10	29.5
AMER ARCHER	AMERICAN	12	48.3 N	15.7 W	12	29		42	10 NM	02	999.5	8.9	11.1	9	24.5	29	10	32.5
CHARLESTON	AMERICAN	16	35.3 N	75.0 W	12	02		45	10 NM	05	1013.2	12.8		2	10	02	< 6	16.5
AMER LEADER	AMERICAN	18	47.0 N	48.1 W	18	31		48	.5 NM	71	991.0	0.2	- 1.1	6	5	35	10	10
AMER LEADER	AMERICAN	19	46.1 N	50.2 W	00	31		48	.5 NM	71	1007.0	0.5	0.0	6	5	35	10	10
NOPAL SEL	NORWEGIAN	20	38.5 N	29.4 W	18	30	M	45	10 NM	02	1021.0	13.0	15.0	XX	11.5	27	X	13
AMER ARGOSY	AMERICAN	20	50.5 N	29.0 W	18	31		50	2 NM	63	992.9	5.5	10.0	6	10	31	>13	32.5
AMER ARGOSY	AMERICAN	21	50.5 N	29.6 W	00	32		55	2 NM	02	1001.0	6.7	10.0	4	14.5	32	>13	41
EXPORT PATRIOT	AMERICAN	21	50.6 N	30.3 W	06	34		48	5 NM	02	1009.1	5.0	11.1	4	14.5	32	7	29.5
STAGHOUND	AMERICAN	21	40.2 N	55.9 W	18	18		50	2 NM	18	1002.1	18.3	15.0	9	29.5			
EXXON NEW ORLEANS	AMERICAN	25	40.2 N	70.2 W	18	25		45	5 NM	02	999.0	13.6	5.5	15	24.5			
LOS ANGELES	AMERICAN	26	41.1 N	36.7 W	06	29		45	2 NM	91	994.2	9.4	18.9	5	5	30	< 6	14.5
SEALAND PRODUCER	AMERICAN	26	38.7 N	23.5 W	12	11		43	1 NM	30	1010.0	8.7	4.4	7	10	XX	X	11.5
YELLOWSTONE	AMERICAN	27	32.2 N	26.0 W	18	20		45	10 NM	02	1011.2	20.0	17.8	6	8	XX	X	13
HOEGH MISTRAL	NORWEGIAN	27	33.5 N	46.7 W	12	30		56	5 NM	02	998.3	19.0						
SEALAND MARKET	AMERICAN	27	36.5 N	23.5 W	12	19		41	5 NM	05	1007.1	16.2	12.8	6	8	26	6	13
DOCTOR LYKES	AMERICAN	28	35.9 N	26.0 W	12	18		48	5 NM	02	1000.0	17.8	15.6	4	11.5	18	8	16.5
SEALAND PRODUCER	AMERICAN	28	48.7 N	48.3 W	12	32		45	5 NM	02	1000.4	5.0	- 1.6	5	10	32	6	11.5
OCEAN STATION VESSELS																		
ATLANTIC M																		
TANEY	AMERICAN	1	38.0 N	71.0 W	18	30	M	41	10 NM	02	1008.6	5.0	18.5	6	10			
DUANE	AMERICAN	4	38.0 N	71.0 W	03	23	M	41	10 NM	02	1005.0	15.4	22.1	8	14.5			
DUANE	AMERICAN	6	38.0 N	71.0 W	06	31	M	48	5 NM	07	1002.5	0.5	19.0	8	19.5			
SHERMAN	AMERICAN	23	38.0 N	71.0 W	03	24	M	45	10 NM	02	1017.3	17.1	21.3	5	11.5			
TANEY	AMERICAN	25	38.0 N	71.0 W	06	27	M	47	5 NM	01	1000.6	18.2	20.5	5	11.5	17	8	10
TANEY	AMERICAN	26	38.0 N	71.0 W	00	27	M	49	5 NM	07	1007.8	16.1	19.3	7	16.5			

+ Direction for sea waves same as wind direction
X Direction or period of waves indeterminate
M Measured wind

NOTE: The observations are selected from those with winds ≥ 35 kn or waves ≥ 25 ft from May through August (≥ 41 kn or ≥ 33 ft, September through April). In cases where a ship reported more than one observation a day with such values, the one with the highest wind speed was selected.

Table 9
Selected Gale and Wave Observations, North Pacific
January and February 1977

Vessel	Nationality	Date	Position of Ship		Time GMT	Wind			Visibility n. mi.	Present Weather code	Pressure mb.	Temperature °C		Sea Waves†			Swell Waves		
			Lat. deg.	Long. deg.		Dir. 10°		Speed kt.				Air	Sea	Period sec.	Height ft.		Dir. 10°	Period sec.	Height ft.
NORTH PACIFIC OCEAN		JAN.																	
GLORIOUS SHINKO	LIBERIAN	1	30.5 N	155.0 E	18	28	M	50	10	NM 03	1005.2	16.5	18.0	6	16.5		28	6	19.5
GOLDENROD	LIBERIAN	1	35.5 N	152.4 E	18	31	M	44	1	NM	1002.5	7.5	19.0	4	6.5		31	10	13
ALEUTIAN DEVELOPER	AMERICAN	1	36.4 N	157.4 W	00	14		47	5	NM 02	977.3	- 0.5	5.5	5	8		14	7	13
PACIFIC BEAR	AMERICAN	1	35.4 N	161.3 E	00	29	M	42	10	NM 18	1003.0	10.0	17.2	8	19.5		32	>13	29.5
MONTIRON	LIBERIAN	1	43.3 N	171.9 W	18	25	M	44	10	NM 01	989.9	5.2	8.0	5	13		24	13	26
CRESSIDA	PANAMANIAN	2	40.9 N	178.0 E	18	09	M	45	5	NH 63	972.0	5.5	9.5	6	16.5		09	12	16.5
REISHU MARU	JAPANESE	2	47.0 N	169.3 W	00	22	M	42	2	NH 27	986.3	5.0	4.5	4	6.5		22	7	18
GOLDENROD	LIBERIAN	2	35.8 N	154.1 E	00	32	M	46	2	NH 27	1001.0	9.5	19.5	4	6.5		32	10	13
GLORIOUS SHINKO	LIBERIAN	2	30.7 N	153.5 E	06	30	M	50	10	NM 02	1011.4	16.5	18.0	5	18		30	< 6	24.5
ARCO JUNEAU	AMERICAN	2	49.7 N	130.3 W	18	31		50	2	NM 20	996.0	7.8	12.2	8	24.5		33	>13	49
ARCO SAG RIVER	AMERICAN	2	47.1 N	132.5 W	18	32		48	2	NH 16	1000.3	11.0	10.0	3	13		30	7	24.5
ANCO DUKE	BRITISH	2	33.3 N	151.5 E	06	29		45	5	NM 81	1009.0	10.0	21.1	9	24.5				
SEALAND COMMERCE	AMERICAN	2	33.1 N	157.4 E	06	29		46	5	NM 62	1001.5	12.8	15.6	9	18		29	>13	28
GLORIOUS SHINKO	LIBERIAN	3	32.2 N	146.6 E	18	27	M	55	2	NM 81	1008.5	14.0	18.0	8	16.5		27	6	19.5
MONTIRON	LIBERIAN	3	46.6 N	158.0 W	12	13	M	44	5	NM 10	975.0	9.3	6.0				13	12	10
PACIFIC BEAR	AMERICAN	3	36.0 N	170.0 W	18	25	M	52	5	NM 02	991.1	11.1	13.3	5	11.5		25	9	18
MAINE	AMERICAN	3	30.1 N	177.9 E	00	28		42	2	NM 02	997.0	17.5	17.2	6	10		28	9	14.5
JAPAN CADDO	LIBERIAN	3	30.8 N	176.7 E	00	30		43	5	NM 02	1000.5	19.0	19.0						
PACIFIC BEAR	AMERICAN	4	36.0 N	167.4 W	00	27	M	50	5	NM 16	997.0	9.4	13.9	5	13		25	10	24.5
NEWARK	AMERICAN	4	58.1 N	148.4 W	06	13		50	5	NM 62	997.3	4.5					13	8	16.5
MONTIRON	LIBERIAN	4	46.5 N	155.3 W	00	15	M	46	10	NM 02	973.5	10.0	6.0	9	19.5		14	>13	31
ASIA BEAUTY	LIBERIAN	4	53.8 N	150.1 W	06	15	M	47	30	YD 53	987.5	7.0	3.0	9	16.5		13	8	19.5
WORLD HERCULES	JAPANESE	4	32.2 N	177.7 E	18	18	M	43	.5	NM	991.0	18.0	17.0	8	13				
GLORIOUS SHINKO	LIBERIAN	4	32.3 N	146.2 E	00	32	M	45	5	NM 80	1014.2	13.0	18.0	8	16.5		32	>13	23
HONSHU MARU	JAPANESE	5	47.2 N	164.9 W	12	13	M	48	.5	NM 61	975.7	4.5	4.5						
ADRIAN MAERSK	DANISH	5	35.6 N	157.1 W	18	17		45	2	NM 81	998.0	15.0	14.0	6	19.5				
CRESSIDA	PANAMANIAN	5	47.7 N	160.3 W	18	15	M	45	2	NM 63	988.0	7.0	5.2	7	19.5		15	>13	16.5
ZIM HONGKONG	LIBERIAN	5	33.7 N	165.6 W	12	20		43	.25	NM 64	998.0	17.2		7	10		17	9	13
PLUVIUS	GERMAN	5	36.1 N	174.5 W	00	24		45	5	NM 21	980.5	14.6	13.8	10	14.5		XX	X	13
PRES VAN BUREN	AMERICAN	6	35.7 N	148.0 E	06	32		44	10	NM 02	1011.9	8.9	16.1	6	11.5				
KYOJU MARU	JAPANESE	6	47.6 N	168.4 W	00	26	M	42	5	NM 21	960.0	3.5	4.0	3	10		20	9	13
ASIA BEAUTY	LIBERIAN	6	54.1 N	163.1 W	00	11	M	55	30	YD 53	987.0	6.0	3.0	13	32.5				
ADRIAN MAERSK	DANISH	6	35.6 N	154.9 W	00	17		48	2	NM 62	994.5	17.5	14.0	9	21				
SEALAND TRADE	AMERICAN	6	49.0 N	161.4 E	18	32		45	10	NM 02	985.0	- 1.7	2.7	5	10		27	6	16.5
CRESSIDA	PANAMANIAN	6	47.9 N	160.1 W	00	14	M	50	1	NM 04	982.0	7.0	5.0	8	19.5				
INDIAN MAIL	AMERICAN	7	36.3 N	173.0 E	12	29		00	10	NM 18	1004.4	7.2	15.0	7	18		29	10	29.5
AMER APOLLO	AMERICAN	7	37.4 N	174.1 E	00	27		48	5	NM 02	996.3	12.2	13.3	8	26				
SEALAND TRADE	AMERICAN	7	47.4 N	158.9 E	00	27		45	10	NM 88	993.5	- 3.3	1.6	5	13		24	< 6	10
BREWSTER	PANAMANIAN	7	43.2 N	176.1 E	18	27	M	55	200	YD 40	969.0	1.0	7.0	3	6.5		27	>13	13
PRESIDENT MADISON	AMERICAN	7	52.7 N	171.3 E	00	24		42	10	NM 27	980.3	0.6	1.7	4	14.5				
BREWSTER	PANAMANIAN	8	42.9 N	178.2 W	12	28	M	49	.5	NM 27	978.0	2.0	8.0	4	6.5		27	8	13
PRESIDENT MADISON	AMERICAN	8	46.9 N	157.1 E	12	27		44	5	NM 26	998.2	- 5.0	0.6	5	11.5		27	7	24.5
SUCCESSFUL VENTURE	LIBERIAN	9	38.6 N	163.5 E	18	30	M	43	1	NM 01	1010.9	5.5	12.0	10	16.5		30	8	19.5
BREWSTER	PANAMANIAN	9	42.7 N	174.8 W	00	27	M	44	10	NM 17	979.8	7.0	9.0	4	6.5		27	8	13
PRESIDENT MADISON	AMERICAN	9	43.5 N	151.4 E	06	32		55	5	NM 70	1015.3	- 7.7	0.0	7	19.5				
ALASKA STANDARD	AMERICAN	9	55.7 N	158.6 W	00	11		44	> 45	NM 02	1009.1	5.0	10.0	3	8		14	7	13
SUCCESSFUL VENTURE	LIBERIAN	10	38.4 N	165.4 E	00	28	M	53	.5	NM 99	1006.0	5.5	13.0	12	13		28	12	26
OCTA	LIBERIAN	10	30.5 N	175.4 E	00	29	M	42	5	NM 81	1006.2	16.0	19.0	14	24.5				
OLGA TOPIC	LIBERIAN	10	47.4 N	166.0 E	18	32		49	2	NM 80	982.0	1.0	6.0	12	18				
NOPAL SEL	NORWEGIAN	10	33.9 N	168.7 E	00	32	M	46	10	NM 02	1009.5	11.0		10	8		34	>13	16.5
EXPORT COURIER	AMERICAN	11	36.0 N	161.1 E	12	29	M	45	10	NM 02	1002.2	10.3	15.6	3	10		29	8	19.5
KOREA PHOENIX	SINGAPORE	11	34.7 N	170.2 W	05	27	M	50	5	NM 50	995.3	9.0					27	9	14.5
OCTA	LIBERIAN	11	30.3 N	168.1 E	12	27	M	45	1	NM 81	1002.0	17.0	19.0	14	24.5				
KOREA PHOENIX	SINGAPORE	12	34.6 N	178.2 W	17	31	M	45	1	NM 10	1002.0	9.5					28	< 6	11.5
EXPORT COURIER	AMERICAN	12	36.7 N	159.6 E	06	32	M	45	10	NM 02	1009.2	10.0	16.2	2	8		32	8	23
VAN WARRIOR	LIBERIAN	12	31.4 N	164.8 W	18	04		45	5	NM 03	982.0	7.0	4.0						
TRANSONEIDA	AMERICAN	12	30.4 N	153.2 W	18	23		45	5	NM 63	1008.0	18.3	20.0	5	10		27	8	16.5
KOREA PHOENIX	SINGAPORE	13	34.6 N	175.8 E	17	25	M	45	.5	NM 28	1001.0	12.0					26	< 6	10
MEDELENA	FRENCH	13	30.8 N	153.2 W	12	26	M	50	5	NM 01	1007.0	17.4	18.5	3	10		26	6	13
NOPAL SEL	NORWEGIAN	13	33.2 N	166.5 W	00	27	M	45	5	NM 51	999.5	14.5	17.0	5	10		27	10	16.5
ROMANDIE	SWISS	13	30.6 N	161.1 W	06	29	M	45	5	NM 02	1007.5	15.5	18.0	4	13		29	10	19.5
ALASKA STANDARD	AMERICAN	13	55.7 N	159.8 W	12	08		58	5	NM 07	973.6	5.0	7.8	6	14.5				
VAN WARRIOR	LIBERIAN	13	51.0 N	172.5 W	18	32		55	1	NM 69	963.0	6.0	4.0						
LONG BEACH	PANAMANIAN	14	45.1 N	144.4 W	18	15	M	44	2	NM 07	980.0	10.0	3.5	8	18				
KOREA PHOENIX	SINGAPORE	14	34.6 N	170.6 E	11	27	M	50	1	NM 81	988.5	15.0					29	< 6	10
EXPORT COURIER	AMERICAN	14	35.5 N	178.1 W	18	25	M	43	5	NM 03	983.0	16.2	14.4	6	23		25	7	32.5
VAN WARRIOR	LIBERIAN	14	50.7 N	177.1 W	12	27		35	1	NM 71	954.0	4.0	4.0						
KOREA PHOENIX	SINGAPORE	15	34.6 N	166.4 E	05	30	M	45	1	NM 81	996.5	11.5					32	< 6	10
JUTHLANDIA	LIBERIAN	15	32.1 N	175.7 E	00	27		45	10	NM 01	994.0	17.0	14.0				27	12	16.5
LEO	LIBERIAN	15	48.1 N	155.3 W	18	08	M	50	.25	NM 07	950.0	4.0	3.0	8	29.5				
JAPAN RAINBOW	JAPANESE	15	29.9 N	171.5 W	18	23	M	54	5	NM 03	1003.0	23.0	22.0						
LONG BEACH	PANAMANIAN	15	48.9 N	143.7 W	00	31	M	45	.5	NM 25	997.3	8.0	3.8	9	16.5				
NEWARK	AMERICAN	15	55.7 N	144.5 W	12	09		45	5	NM 10	988.2	4.4	4.4	5	10		XX	X	19.5
MEDELENA	FRENCH	15	29.1 N	167.2 W	18	25	M	45	5	NM 03	993.0	21.4	19.5	3	8		26	< 6	29.5
CORAL ARCADIA	LIBERIAN	15	30.0 N	166.3 E	18	35	M	44	10	NM 20	983.0	1.0	3.0	11	23				
AUSTRAL MOON	AMERICAN	15	41.3 N	147.7 W	18	20	M	44	5	NM 51	988.1	13.4	9.5	8	14.5				
SUCCESSFUL VENTURE	LIBERIAN	15	42.9 N	151.5 W	18	22	M	43	2	NM 02	980.0	10.5	10.5	4	10		23	< 6	13
PRES PIERCE	AMERICAN	16	36.9 N	172.5 E	06	31		45	5	NM 16	999.6	5.1	13.5	7	13				
CHEVRON MISSISSIPPI	AMERICAN	16	56.2 N	147.4 W	18	18		45	10	NM 02	976.5	4.5	3.8	4	11.5		18	< 6	14.5
UNIVERSE KURE	LIBERIAN	16	34.3 N	178.7 W	00	29	M	45	10	NM 27	999.1	8.5	15.5	7	16.5		32	11	21
VAN WARRIOR	LIBERIAN	16	50.0 N	171.3 E	06	36		50	2	NM 50	975.0	5.0	4.0						
JAPAN RAINBOW	JAPANESE	16	24.8 N	169.7 W	00	22	M	54	5	NM 02	1003.0	24.0	23.0	10	14.5				
OLGA TOPIC	LIBERIAN	16	49.7 N	147.5 W	06	22		48	5	NM 01	973.5	8.0	7.0	10	29.5				
MILLYER BROWN	AMERICAN	17	59.0 N	151.6 W	12	07		50	5	NM 82	962.0	4.4	1.7						
CHEVRON MISSISSIPPI	AMERICAN	17	55.5 N	146.3 W	00	09		50	5	NM 02	973.5	4.4	3.9	5	14.5		21	7	19.5
SANTA CLARA	AMERICAN	17	55.2 N	143.5 W	12	21		50	10	NM 01	985.1	5.0	5.5	5	23				
OCEAN LOG	JAPANESE	17	48.7 N	132.5 W	00	15	M	42	30	YD 58	1008.0	10.0	10.0	7	11.5				
ALASKA STANDARD	AMERICAN	17	58.1 N	151.7 W	06	08		55	5	NM 63	966.0	4.8	8.3	3	10		06	6	18
VAN WARRIOR	LIBERIAN	18	44.5 N	155.6 E	18	32		45	5	NM 01	1006.0	3.0	4.0						

Vessel	Nationality	Date	Position of Ship		Time GMT	Wind		Visibility n. mi.	Present Weather code	Pressure mb.	Temperature °C		Sea Waves*		Swell Waves		
			Lat. deg.	Long. deg.		Dir. 10°	Speed kt.				Air	Sea	Period sec.	Height ft.	Dir. 10°	Period sec.	Height ft.
NORTH PACIFIC OCEAN		JAN.															
KOREA PHOENIX	SINGAPORE	19	34.5 N	139.0 E	11	31	M 45	2 NM	02	1014.5	12.0				32	< 6	5
PHILADELPHIA	AMERICAN	19	59.0 N	151.1 W	12	08	45	10 NM	26	1011.2	5.6	5.6	9	8			
MARITIME ACE	PANAMANIAN	20	15.4 N	94.7 W	00	36	M 43	2 NM	05	1015.0	19.0	23.0	9	13			
PHILADELPHIA	AMERICAN	20	56.2 N	141.6 W	12	13	45	5 NM	51	1000.3	6.7	5.6	6	8	16	12	11.5
ROSE	LIBERIAN	20	34.9 N	176.0 E	21	26	M 41	1 NM	03	997.0	19.5	14.0					
ZIM TOKYO	GERMAN	20	40.1 N	167.4 W	00	23	47	5 NM	02	986.0	10.5	15.6	8	23			
MAMMOTH PINE	LIBERIAN	21	39.1 N	161.8 E	06	29	M 51	2 NM	90	995.2	3.6	11.0		16.5			
MEDELENA	FRENCH	21	31.8 N	150.6 E	18	33	M 41	5 NM	13	1005.5	14.5	18.5			30	< 6	6.5
HILLYER BROWN	AMERICAN	21	57.0 N	137.0 W	00	12	45	5 NM	65	992.3	6.7	6.7	4	10	15	8	14.5
ASIA BRAVERY	LIBERIAN	21	42.3 N	156.0 E	06	31	M 47	2 NM	93	996.8	2.0	9.0	2	6.5	31	8	18
OREGON	AMERICAN	22	41.8 N	172.0 W	18	30	45	10 NM	02	982.0	6.7	8.9	5	14.5	27	8	24.5
ZIM TOKYO	GERMAN	22	38.9 N	139.2 W	12	10	44	5 NM	00	1017.0	13.0	13.0					
LING YUNG	CHINESE	23	42.6 N	171.1 W	00	28	M 41	5 NM	03	983.0	11.0	9.0	12	29.5	25	10	19.5
ROSE	LIBERIAN	23	36.6 N	168.9 W	03	18	M 48	5 NM	03	988.0	12.5	12.0					
CRESSIDA	PANAMANIAN	23	48.6 N	154.1 W	00	14	M 55	.25 NM	45	993.0	7.0	5.0	10	23	14	10	26
LING YUNG	CHINESE	24	44.8 N	162.5 W	00	23	M 42	2 NM	03	967.0	9.0	9.0	3	8	22	6	23
HONGKONG MAIL	AMERICAN	24	34.5 N	151.8 E	06	35	70	200 YD	64	993.2	6.7	17.7	4	14.5			
CHEVRON WASHINGTON	AMERICAN	24	57.9 N	148.9 W	06	13	45	10 NM	21	1009.0	5.0				13	6	13
CRESSIDA	PANAMANIAN	24	48.8 N	160.8 W	06	16	M 55	5 NM	03	969.0	6.5	5.2	10	24.5	16	>13	24.5
HONGKONG PHOENIX	SINGAPORE	25	32.3 N	177.4 W	18	23	41	2 NM	07	990.5	15.0	18.0	8	24.5			
SHUNWIND	LIBERIAN	25	36.9 N	169.3 E	03	33	M 45	5 NM	02	976.0	8.0	16.0	6	23			
TASMANIC	SWEDISH	25	30.3 N	172.7 E	12	29	45	2 NM	01	1002.1	14.0	18.3					
ARNOLD MAERSK	DANISH	25	37.7 N	175.8 W	18	23	45	5 NM	02	962.0	11.5		6	26			
ASIA BRAVERY	LIBERIAN	25	41.8 N	168.9 W	18	12	M 52	200 YD	45	979.5	8.0	10.0	3	6.5	12	8	23
ANCO PRINCESS	BRITISH	25	34.6 N	162.1 E	00	27	49	2 NM	82	1000.0	4.0				27	7	14.5
PLUVIUS	GERMAN	25	30.0 N	170.0 E	06	29	55	5 NM	81	1001.5	15.3	18.0	9	26			
PRES JEFFERSON	AMERICAN	25	41.8 N	151.0 W	12	33	41	5 NM	61	992.2	7.2	8.3	5	6.5			
CHALMETTE	LIBERIAN	25	29.5 N	179.5 W	18	28	55	2 NM	02	1002.0	16.0	19.0	10	16.5	28	>13	19.5
HONGKONG PHOENIX	SINGAPORE	26	32.1 N	178.0 W	00	27	45	2 NM	03	997.0	13.0	15.0	14	29.5			
MAMMOTH PINE	LIBERIAN	26	42.0 N	160.6 W	06	14	M 41	5 NM	91	990.6	9.0	11.0	8	10			
WASHINGTON RAINBOW	JAPANESE	26	34.7 N	171.6 W	00	26	M 57	2 NM	07	984.0	13.0	15.0	3	10	24	12	41
ASIA BRAVERY	LIBERIAN	26	42.3 N	168.8 W	00	15	M 42	2 NM	01	971.5	12.0	10.0	3	8	13	8	19.5
ARNOLD MAERSK	DANISH	26	37.1 N	174.9 W	03	28	63	2 NM	03	975.5	13.0	11.0			28	10	30.5
PRES JEFFERSON	AMERICAN	26	41.2 N	146.0 W	00	22	46	5 NM	02	1001.4	10.0	10.0	6	8	20	9	19.5
CHALMETTE	LIBERIAN	26	29.5 N	179.7 E	06	29	55	5 NM	02	1007.5	14.6	19.5	10	16.5	29	9	19.5
KOREA PHOENIX	SINGAPORE	27	24.5 N	120.3 E	05	04	M 48	1 NM	28	1017.5	11.0				04	< 6	14.5
WASHINGTON RAINBOW	JAPANESE	27	34.1 N	172.2 W	00	27	M 45	5 NM	18	997.0	10.0	14.0	2	10	28	X	41
ASIA BRAVERY	LIBERIAN	27	42.5 N	165.0 W	00	21	M 43	1 NM		974.0	8.0	10.0	2	5	21	11	24.5
ARNOLD MAERSK	DANISH	27	36.3 N	175.2 W	00	32	50	10 NM	01	993.2	9.5	12.0	8	32.5			
SHUNWIND	LIBERIAN	27	36.3 N	178.7 E	06	31	M 45	10 NM	02	1008.0	9.2	15.0					
CHALMETTE	LIBERIAN	27	29.4 N	177.0 E	00	31	50	5 NM	02	1016.0	15.5	19.0	10	16.5	29	9	19.5
PRESIDENT MADISON	AMERICAN	28	35.6 N	156.8 E	00	36	50	5 NM	60	992.8	12.2	15.6	5	18	21	7	19.5
CHALMETTE	LIBERIAN	28	30.7 N	169.8 E	12	13	55	2 NM	64	999.7	18.0	17.5	10	16.5			
CRESSIDA	PANAMANIAN	29	46.1 N	160.1 E	12	24	M 50	2 NM	03	969.0	0.0	1.4	8	16.5			
CHALMETTE	LIBERIAN	29	32.1 N	163.6 E	18	28	45	5 NM	63	997.2	19.5	18.0	6	11.5	XX	X	13
MEDELENA	FRENCH	30	34.6 N	161.8 E	06	29	M 45	10 NM	02	1003.5	10.6	16.5	5	10	29	6	32.5
CHALMETTE	LIBERIAN	30	32.4 N	160.2 E	12	31	45	5 NM	02	1009.0	10.8	16.0	8	13	30	11	16.5
CRESSIDA	PANAMANIAN	30	45.5 N	157.0 E	06	26	M 50	.25 NM	94	991.0	1.0	1.3	9	29.5	26	9	32.5
SHUNWIND	LIBERIAN	31	45.3 N	155.9 W	06	21	M 51	.5 NM	58	984.0	8.1	10.0	7	19.5	21	9	29.5
NORTH PACIFIC OCEAN		FEB.															
MEDELENA	FRENCH	1	36.1 N	177.8 W	12	28	M 45	2 NM	51	992.5	10.8	12.0	3	14.5	29	6	24.5
CHALMETTE	LIBERIAN	1	33.5 N	147.6 E	18	27	45	2 NM	62	1007.0	11.5	15.0	3	13			
CRESSIDA	PANAMANIAN	1	39.6 N	144.1 E	12	24	M 48	5 NM	03	1008.0	0.0	7.3	9	11.5			
PRES VAN BUREN	AMERICAN	2	52.7 N	177.4 E	06	05	42	5 NM	85	981.0	0.0	1.1			05	8	16.5
CHALMETTE	LIBERIAN	2	33.5 N	142.2 E	18	28	45	5 NM	07	1007.0	10.0	15.0	8	14.5			
WASHINGTON RAINBOW	JAPANESE	2	33.9 N	161.5 E	00	23	M 43	5 NM	02	1000.5	18.0		4	8	23	6	11.5
MEDELENA	FRENCH	3	37.0 N	161.2 W	06	27	M 48	2 NM	02	1000.6	11.0	12.0	3	6.5	27	6	24.5
GOLDEN MARINER	PANAMANIAN	3	53.7 N	160.9 W	00	23	M 43	10 NM	03	986.6	3.0	0.0	6	11.5	24	9	16.5
WASHINGTON RAINBOW	JAPANESE	3	33.9 N	153.3 E	12	30	M 43	2 NM	03	1009.0	10.0	16.5			26	< 6	8
ALVA MAERSK	DANISH	3	53.6 N	160.6 W	06	17	47	5 NM	03	976.0	6.5	1.0	12	23			
ANCO DUKE	BRITISH	3	34.9 N	150.5 W	00	25	40	5 NM	03	1000.5	15.5	16.7	7	24.5	26	9	32.5
PRES VAN BUREN	AMERICAN	4	47.4 N	159.2 E	00	07	43	.5 NM	22	985.4	0.6	0.0	5	11.5	07	6	24.5
ANCO DUKE	BRITISH	4	34.8 N	153.4 W	00	28	45	5 NM	25	1002.5	11.5	15.6			26	9	36
ANCO DUKE	BRITISH	5	34.4 N	155.5 W	00	22	45	2 NM	81	1001.5	15.5	15.5	5	24.5	24	10	32.5
JAPAN RAINBOW	JAPANESE	5	42.1 N	151.4 W	06	18	M 50	2 NM	05	987.0	8.5	9.0			XX	X	19.5
GREAT LAND	AMERICAN	6	56.6 N	142.7 W	18	17	M 42	5 NM	05	986.1	6.7	6.7	8	6.5			
PLUVIUS	GERMAN	6	35.9 N	173.6 E	06	19	47	1 NM	62	973.2	17.0	15.0	9	18			
ANCO DUKE	BRITISH	6	34.6 N	159.4 W	06	28	60	2 NM	97	1012.0	11.0	15.6			28	8	26
JAPAN RAINBOW	JAPANESE	6	40.3 N	154.5 W	06	27	M 42	5 NM	25	999.6	8.0	9.0					
ASIA BEAUTY	LIBERIAN	7	48.6 N	134.5 W	00	23	M 52	200 YD	05	998.0	10.0	7.0	9	16.5	23	9	32.5
MUNRO	AMERICAN	7	51.2 N	179.3 W	00	06	M 44	2 NM	71	973.9	2.0	4.4	11	8	13	6	3
MORNING GLORY	LIBERIAN	8	48.0 N	174.3 W	18	26	M 52	2 NM	68	974.0	4.0	5.0	9	16.5			
MORNING GLORY	LIBERIAN	9	48.0 N	172.7 W	00	25	M 52	10 NM	70	977.5	3.5	5.0	9	16.5	24	11	21
MAMMOTH PINE	LIBERIAN	10	49.0 N	129.8 W	12	22	M 42	5 NM	02	991.7	10.3	10.0		13	30	X	19.5
ORIENTAL EDUCATOR	BRITISH	10	29.0 N	129.5 E	06	33	M 47	10 NM	01	1018.6	16.0	18.0	8	8	33	10	11.5
HILLYER BROWN	AMERICAN	10	50.3 N	129.2 W	06	14	48	5 NM	63	996.3	8.9	9.4	4	8			
POLAR SEA	AMERICAN	10	44.7 N	125.0 W	12	21	M 43	2 NM	07	1014.9	12.2		6	13			
VAN WARRIOR	LIBERIAN	10	37.0 N	153.5 E	18	11	45	2 NM	63	989.0	10.0	16.0					
ANCO DUKE	BRITISH	10	34.8 N	178.1 W	00	27	50	10 NM	15	999.8	8.0	15.6	6	16.5	27	7	23
JAPAN RAINBOW	JAPANESE	11	40.9 N	177.6 E	18	36	M 65	2 NM		996.9	1.0	9.0					
ANCO DUKE	BRITISH	11	34.6 N	177.5 E	12	23	56	2 NM	81	987.0		15.6	6	32.5			
MAMMOTH PINE	LIBERIAN	12	51.9 N	143.6 W	12	21	M 45	5 NM	01	978.7	5.3	7.0		11.5	23	X	19.5
MORNING GLORY	LIBERIAN	12	48.2 N	146.5 W	06	23	M 50	10 NM	01	983.0	6.5	7.0	6	10	18	10	10
JAPAN RAINBOW	JAPANESE	12	40.8 N	176.4 E	00	32	M 50	5 NM	68	998.5	1.0	9.0			32	8	16.5
ORIENTAL SOVERIGN	LIBERIAN	12	50.0 N	169.1 W	12	09	M 45	10 NM	02	985.0	3.0	4.0	5	10	09	< 6	13
GOLDEN ANNE	BRITISH	12	41.7 N	168.9 W	06	19	50	5 NM	02	958.0	7.0	6.0	5	14.5	19	7	19.5
SANTA CLARA	AMERICAN	12	51.0 N	136.5 W	18	21	45	5 NM	50	998.6	6.7	8.3			21	8	26
VANGUARD	LIBERIAN	12	35.9 N	160.8 E	02	29	M 55	2 NM	23	1008.0	12.0	17.0					
ASIA BRIGHTNESS	LIBERIAN	12	38.7 N	179.9 W	00	27	50	5 NM	26	982.0	6.0	12.0	6	26			
MIDGETT	AMERICAN	13	37.0 N	122.4 W	00	35	M 43	2 NM	10	1024.4	13.4	13.8	4	5			
JAPAN RAINBOW	JAPANESE	13	40.3 N	167.6 E	18	29	M 50	2 NM	68	1006.0	2.0	11.0					
GOLDEN ANNE	BRITISH	13	42.8 N	162.9 W	00	20	50	5 NM	02	969.0	7.0	8.0	7	16.5	20	9	19.5
ASIA HONESTY	LIBERIAN	13	51.8 N	136.0 W	00	22	M 48	5 NM	03	1008.0	9.0	10.0		16.5	29	9	24.5
ASIA BRIGHTNESS	LIBERIAN	13	39.3 N	171.4 E	06	28	45	5 NM	03	987.0	7.0	11.0					
SANTA CLARA	AMERICAN	13	51.0 N	135.1 W	00	20	50	10 NM	01	1012.5	8.3	8.3			25	>13	32.5
VANGUARD	LIBERIAN	14	35.9 N	174.2 E	00	29	M 41	2 NM	01	1014.0	10.0	17.0					
OCTA	LIBERIAN	15	37.5 N	144.2 E	12	05	M 42	.25 NM	13	995.4	2.0	16.0	12	19.5			
VIOLET	LIBERIAN	15	38.2 N	146.0 E	12	02	M 45	2 NM	63	995.5	4.0	15.0	4	8	05	6	13

Vessel	Nationality	Date	Position of Ship		Time GMT	Wind		Visibility n. mi.	Present Weather code	Pressure mb.	Temperature °C.		Sea Waves?		Swell Waves		
			Lat. deg.	Long. deg.		Dir. 10°	Speed kt.				Air	Sea	Period sec.	Height ft.	Dir. 10°	Period sec.	Height ft.
NORTH PACIFIC OCEAN		FEB.															
CRESSIDA	PANAMANIAN	15	37.9 N	148.2 E	18	05 M	50	1 NM	58	988.0	7.0	14.2	10	26	05	12	29.5
OCTA	LIBERIAN	16	35.1 N	150.1 E	12	26 M	42	2 NM	13	1003.8	10.5	16.0	14	24.5			
AMER AQUARIUS	AMERICAN	16	35.5 N	155.7 E	00	25	45	5 NM	01	997.5	13.3	14.4	10	19.5	25	>13	23
ANCO DUKE	BRITISH	16	34.6 N	157.5 E	12	26	45	2 NM	01	1002.0	14.0	16.7	8	26	27	9	32.5
VIOLET	LIBERIAN	16	39.5 N	148.6 E	00	03 M	45	5 NM	02	997.0	4.0	15.0	4	10	04	7	16.5
CRESSIDA	PANAMANIAN	16	37.9 N	149.6 E	00	01 M	43	2 NM	58	994.0	12.0	16.8	10	23	02	13	28
PLUTOS	GERMAN	16	31.7 N	150.8 E	00	26	44	5 NM	02	1008.2	15.5		8	23	26	12	29.5
SAN BRUNO	SWEDISH	16	35.0 N	153.5 E	06	25	45	10 NM	03	999.0	13.8				25	12	24.5
ANDERS MAERSK	DANISH	17	34.9 N	163.5 W	18	26	42	2 NM	02	998.3	14.0	12.0	12	13			
WYOMING	AMERICAN	17	44.5 N	160.2 W	06	08	45	5 NM	61	973.7	3.5	6.1	3	10	09	8	24.5
VANGUARD	LIBERIAN	17	37.0 N	164.4 W	00	23 M	45	.25 NM	60	998.0	19.0	16.0					
CRESSIDA	PANAMANIAN	17	38.5 N	153.8 E	00	02 M	48	10 NM	03	997.0	12.0	12.5	6	23			
GOLDEN MARINER	PANAMANIAN	17	44.2 N	145.9 W	15	21 M	48	1 NM	81	996.1	10.0	8.5	6	13	20	9	14.5
PINE LIGHT	LIBERIAN	17	38.2 N	174.2 E	00	27	52	200 YD	46	993.0	13.0	11.0	7	19.5	27	7	23
PLUTOS	GERMAN	17	32.5 N	148.4 E	00	28	42	5 NM	82	1010.4	12.0		8	26	28	>13	29.5
OCTA	LIBERIAN	17	34.5 N	153.4 E	00	27 M	45	5 NM	02	1005.0	12.0	15.0	14	24.5			
LAUREL	LIBERIAN	17	47.6 N	167.5 W	18	36 M	42	10 NM	03	987.0	3.0	9.0	4	8	07	< 6	10
LONG BEACH	PANAMANIAN	17	39.1 N	150.2 W	12	30 M	30	200 YD	42	1002.5	12.0	9.5	7	8			
NARCONA EXPORTER	LIBERIAN	17	31.0 N	145.8 E	06	29	40	10 NM	01	1013.0	14.0	17.0	6	10	28	10	32.5
CRYSTAL REED	PANAMANIAN	18	34.6 N	151.1 W	00	20 M	48	.25 NM	34	1000.9	15.0	15.0	13	32.5			
ANDERS MAERSK	DANISH	18	35.0 N	161.2 W	00	27	35	2 NM	63	999.9	14.5		16	26			
BREWSTER	PANAMANIAN	18	40.9 N	169.3 E	00	29 M	42	10 NM	07	995.4	4.0	10.5			31	6	11.5
GOLDEN MARINER	PANAMANIAN	18	44.7 N	143.1 W	00	18 M	43	1 NM	81	996.6	11.0	9.5	6	13	18	9	14.5
OCEAN LOG	JAPANESE	18	43.3 N	176.6 E	06	10 M	30	200 YD	64	978.0	2.0	4.0	11	16.5			
VAN CONQUEROR	LIBERIAN	18	48.3 N	145.4 W	12	18 M	41	2 NM	50	977.0	3.0	8.0					
VANGUARD	LIBERIAN	18	37.5 N	157.3 W	00	27 M	48	.25 NM	54	987.5	10.0	15.0					
JAPAN ACE	JAPANESE	18	41.1 N	162.2 W	00	32 M	43	2 NM	03	982.0	6.0	7.0	3	5	34	7	16.5
LAUREL	LIBERIAN	18	47.9 N	163.5 W	06	34 M	44	10 NM	01	982.0	4.0	8.0	5	11.5	01	6	14.5
PRES TRUMAN	AMERICAN	19	51.8 N	171.5 E	12	29	45	30 YD	75	991.5	2.5	2.3	2	5			
VANGUARD	LIBERIAN	19	37.8 N	146.7 W	12	22 M	43	.25 NM	92	984.5	13.0	16.0					
HONSHU MARU	JAPANESE	19	42.3 N	141.4 W	18	15 M	42	.5 NM	63	972.7	12.0	9.5	8	14.5	15	10	26
GOLDEN MARINER	PANAMANIAN	20	46.0 N	129.2 W	06	16 M	42	1 NM	80	994.6	11.0	11.5	6	10			
GREAT LAND	AMERICAN	20	53.5 N	135.5 W	18	15 M	44	10 NM	01	973.4	10.3	8.9	7	10			
PLUVIUS	GERMAN	20	30.8 N	143.6 W	00	26	44	5 NM	81	1008.0	19.8	19.5	7	13	27	12	13
PRESIDENT MADISON	AMERICAN	20	48.3 N	134.9 W	18	19	45	5 NM	02	974.8	10.0	8.9	10	14.5	20	12	24.5
TABPING	LIBERIAN	20	50.7 N	150.8 W	18	31	42	2 NM	02	968.0	3.0	5.0	5	19.5	34	7	24.5
CHEVRON COLORADO	AMERICAN	20	49.7 N	134.9 W	06	12 M	50	2 NM	51	981.2	10.6		3	13	13	6	24.5
YEH YUNG	CHINESE	20	46.2 N	143.5 W	06	03 M	20	2 NM	58	954.5	11.0	13.0	5	14.5	07	7	32.5
VANGUARD	LIBERIAN	20	37.9 N	143.3 W	00	27 M	45	1 NM	92	989.5	13.0	18.0					
VAN WARRIOR	LIBERIAN	20	47.4 N	136.8 W	18	20	50	5 NM	03	971.0	9.0	8.0					
VAN CONQUEROR	LIBERIAN	20	48.7 N	135.0 W	06	12 M	50	1 NM	61	974.0	8.0	10.0					
LAKE PALOURDE	LIBERIAN	20	34.9 N	173.0 W	12	29	42	5 NM	03	1012.0	8.3	16.0	6	11.5	28	12	14.5
LAUREL	LIBERIAN	20	49.2 N	144.6 W	06	05 M	41	5 NM	21	959.0	6.0	10.0	6	11.5	08	7	16.5
NEWARK	AMERICAN	20	52.4 N	133.1 W	18	15	50	2 NM	02	978.7	8.9	7.8	10	13	14	10	26
HONSHU MARU	JAPANESE	20	41.5 N	138.7 W	06	23 M	50	.25 NM	65	982.4	10.0	12.5					
JAPAN ACE	JAPANESE	20	38.4 N	142.0 W	00	26 M	48	1 NM	80	985.5	12.0	11.5	3	6.5	26	8	23
HONSHU MARU	JAPANESE	21	40.0 N	133.1 W	06	27 M	36	1 NM		1000.0	10.5	13.0	8	14.5	26	10	39
LAUREL	LIBERIAN	21	49.4 N	138.2 W	00	23 M	50	2 NM	10	986.0	6.0	8.0	6	13	21	12	29.5
NEWARK	AMERICAN	21	52.0 N	132.5 W	00	15	50	5 NM	02	982.7	8.8	7.5	9	14.5	15	10	26
ATLANTIC PIONEER	PANAMANIAN	21	51.7 N	137.9 W	00	19 M	45	5 NM	02	959.0	7.0	7.0	11	14.5	18	>13	24.5
ALEUTIAN DEVELOPER	AMERICAN	21	56.7 N	153.7 W	00	32	47	5 NM	02	976.0	- 3.3	3.2			32	7	10
ALBERT MAERSK	DANISH	21	47.8 N	136.9 W	12	27	41	5 NM	50	988.0	9.2		23		24	X	13
WASHINGTON RAINBOW	JAPANESE	21	32.4 N	160.1 E	18	19 M	43	10 NM	02	1015.0	18.0	19.0	7	8			
VANGUARD	LIBERIAN	21	37.3 N	136.4 W	00	21 M	70	200 YD	81	1000.6	14.0	18.0					
YEH YUNG	CHINESE	21	47.3 N	137.3 W	00	23 M	46	5 NM	01	978.3	10.0	13.0	3	14.5	22	8	49
VAN CONQUEROR	LIBERIAN	21	48.6 N	134.0 W	00	18 M	50	2 NM	02	982.0	8.0	10.0					
VAN WARRIOR	LIBERIAN	21	48.1 N	135.0 W	00	21	45	5 NM	01	980.0	12.0	8.0					
DON JUAN	SWEDISH	21	43.7 N	152.7 E	18	34	56	.25 NM	69	974.5	1.0						
SEALAND FINANCE	AMERICAN	21	50.4 N	139.9 W	18	27	48	10 NM	02	992.9	6.0	6.0	4	26	27	6	39
PRESIDENT MADISON	AMERICAN	21	48.7 N	136.3 W	06	23	47	10 NM	01	980.0	7.8	8.3	10	14.5	20	12	19.5
SEA FAN	SINGAPORE	21	46.7 N	156.0 E	21	04 M	58	200 YD	75	963.0	- 1.0						
TABPING	LIBERIAN	22	52.6 N	173.9 W	18	17	41	2 NM	87	987.0	0.0	4.0	8	13			
TRIUMPH	PANAMANIAN	22	39.6 N	167.4 E	00	22 M	48	10 NM	01	1005.5	11.0	12.0	5	6.5			
ASIA HONESTY	LIBERIAN	22	41.7 N	145.5 E	18	27 M	42	5 NM	68	1005.5	+ 1.5	9.0		10	27	X	13
ASIA BEAUTY	LIBERIAN	22	48.1 N	159.8 E	00	05 M	50	30 YD	75	998.0	- 1.0	0.0	8	13			
HAWAIIAN CITIZEN	AMERICAN	22	46.6 N	127.3 W	00	26	45	5 NM	18	991.5	10.6	12.2	6	16.5			
GOLDENROD	LIBERIAN	22	37.5 N	168.0 E	06	21 M	42	2 NM	10	1005.0	14.0	11.0	5	8	21	8	14.5
PRESIDENT MADISON	AMERICAN	22	50.5 N	143.5 W	18	29 M	41	10 NM	02	1002.6	5.6	5.6	14	19.5			
SEALAND FINANCE	AMERICAN	22	50.5 N	140.5 W	00	26	45	10 NM	02	999.0	5.6	5.6	4	16.5	27	< 6	32.5
SEA FAN	SINGAPORE	22	46.4 N	154.8 E	00	34 M	50	.25 NM	84	971.0	- 2.0						
TABPING	LIBERIAN	23	52.9 N	179.6 E	12	21	62	1 NM	64	967.0	0.0	1.0	20	49	26	>13	21
ARTLO MAERSK	DANISH	23	37.4 N	174.4 W	06	18	42	10 NM	02	1019.6	15.5					X	14.5
SHUNWIND	LIBERIAN	23	53.7 N	168.1 E	06	30 M	50	2 NM	70	953.5	0.5	5.0	5	19.5	22	6	23
TABPING	LIBERIAN	24	53.1 N	177.1 E	00	21	55	1 NM	87	970.0	- 2.0	2.5	13	39	27	>13	19.5
PRESIDENT MADISON	AMERICAN	24	53.4 N	159.5 W	18	28 M	45	5 NM	70	994.8	2.3	3.3	4	16.5	25	7	11.5
NEWARK	AMERICAN	25	52.3 N	132.5 W	12	20	45	5 NM	60	996.3	6.2	7.7	6	10	21	8	16.5
MORNING GLORY	LIBERIAN	25	51.7 N	136.8 W	12	27 M	47	5 NM	50	995.6	8.5	9.0			27	< 6	10
SANTA CLARA	AMERICAN	25	48.7 N	133.1 W	18	28	45	10 NM	01	1012.5	6.2	8.3			28	8	32.5
SHUNWIND	LIBERIAN	25	48.4 N	160.8 E	18	26 M	42	10 NM	01	1001.5	- 6.5	4.0					
PRESIDENT MADISON	AMERICAN	25	54.3 N	168.2 W	12	18 M	45	5 NM	85	998.0	1.1	4.4					
TABPING	LIBERIAN	25	49.2 N	163.3 E	18	27	54	1 NM	86	999.0	- 7.0	1.0					
NEWARK	AMERICAN	26	53.6 N	135.9 W	00	29	45	2 NM	62	1001.4	3.8	7.2	5	10	29	10	23
SANTA CLARA	AMERICAN	26	47.5 N	131.8 W	00	28	40	10 NM	02	1020.3	7.8	10.0			28	8	32.5
PRESIDENT MADISON	AMERICAN	27	50.9 N	164.8 E	12	25 M	45	5 NM	26	989.0	- 6.7	1.7	12	24.5			
PRESIDENT MADISON	AMERICAN	28	48.6 N	156.9 E	12	32 M	48	5 NM	26	1001.2	- 3.9	- 0.6	12	19.5			

\+ Direction for sea waves same as wind direction
X Direction or period of waves indeterminate
M Measured wind

NOTE: The observations are selected from those with winds ≥ 35 kn or waves ≥ 25 ft from May through August (≥ 41 kn or ≥ 33 ft, September through April). In cases where a ship reported more than one observation a day with such values, the one with the highest wind speed was selected.

Rough Log, North Atlantic Weather

April and May 1977

ROUGH LOG, APRIL 1977--As might be expected for a transition month, the storm tracks exhibited very little comparison to the normal climatology. The only track to compare was one from over the Gulf of St. Lawrence into the Labrador Sea which had minimal effect on the shipping lanes. Only one storm moved off or formed off the U.S. East Coast south of Maine. Many more storm centers than normal formed near or traversed the central ocean south of 40°N. They traveled from north to south to east. One reached Scandinavia, and another reached the Iberian Peninsula. Three centers visited the Mediterranean Sea.

The mean pressure pattern was quite different from the long-term mean. There were three low centers over the northern latitudes with the primary and deepest one at 1003 mb near Trondheim, Norway. The other two were over the Labrador Sea. The Azores High ridged into the area between Greenland and Iceland, where the primary Low is normally positioned. The pressure over the middle latitudes was generally 4 mb higher than the climatic mean with the 1020-mb isoline encompassing the area normally covered by the 1016-mb isoline. The high-pressure center at 1026 mb was shifted nearly 10° in both latitude and longitude to 40°N, 20°W.

The primary shipping lanes were influenced by positive anomalies--the most important one being a positive 7-mb center near 50°N, 20°W. Another was a positive 5-mb center off the U.S. East Coast. A negative 9-mb center was near Stockholm.

The upper-air pattern at 700 mb closely matched the long-term mean, except the troughs and ridges were more accented. This particularly applied to the ridge west of the European coast, which in the northern latitudes was also shifted westward.

Extratropical Cyclones--The first storm of the month came from the lee side of the Rocky Mountains. On the 4th it was centered over Newfoundland at 985 mb. The ALERT and two other Canadian vessels off Halifax had 55-kn westerly winds and 20-ft waves. Later in the day the ATLANTICA MILANO had 52-kn winds and 26-ft seas and swells about 400 mi east of Cape Cod. By midday on the 5th, the LOW was battering shipping (fig. 62). The USCGC EVERGREEN near 43.5°N, 49°W, was tossed by 34-ft seas. The SPLIT about 100 mi away had 60-kn winds and 21-ft seas. In the far southeast quadrant a ship was hit by 55-kn winds.

A few days earlier an upper-air HIGH had broken off a ridge of high pressure over midocean and moved northward. At the same time the Greenland surface HIGH drifted southward, and this combination blocked further eastward movement of the LOW. On the 5th it turned southeastward. The ITALICA fought 60-kn winds and 20-ft seas near 40°N, 45°W. Gales up to 45 kn were the general report. At 1800 on the 6th, the GEESTLAND (35°N, 39.5°W) had 50-kn northwesterlies.

Figure 62.--The center of this LOW (50°N, 42°W) is clear--more like a HIGH.

Figure 63.--A mosaic of two tracks shows all the systems.

On the 7th the LOW covered the eastern half of the ocean from the African coast to 45°W and from latitude 20° to 40°N. The anomalous HIGH, centered near 55°N, 30°W, still persisted at 1043 mb. This forced another large LOW to move northward into Baffin Bay (fig. 63).

On the 8th the path of the LOW center looped counterclockwise near 31°N, 30°W. The winds were mild, but the swells were increasing to the 20- to 25-ft range. On the 9th the BORODINO at 25°N, 37°W, was tossed by 31-ft swells. On the 11th the LOW dissipated among the Canary Islands.

The HIGH over the northern waters and the LOW that earlier had moved over Baffin Bay still persisted on the 8th. The circulation around the LOW had expanded to include the Greenland Sea, and a trough formed just north of Iceland. On the 9th a LOW formed in this trough near Scoresby Sound. At 0600 the POSEIDON (63°N, 25°W) found rain, 48-kn winds, and 16-ft seas. By 1200 the MINDEN, near the same position, battled 60-kn winds from the southwest and 30-ft seas which persisted through 1800. At this time this LOW became the primary cyclone as the one over Baffin Bay disappeared (fig. 64). The 984-mb center moved northward on the 10th, and another center of 980 mb formed on the Greenland coast south of Scoresby Sound. The AMBER at 60°N, 35°W, and the buoy at 62°N, 29°W, both reported 45-kn gales.

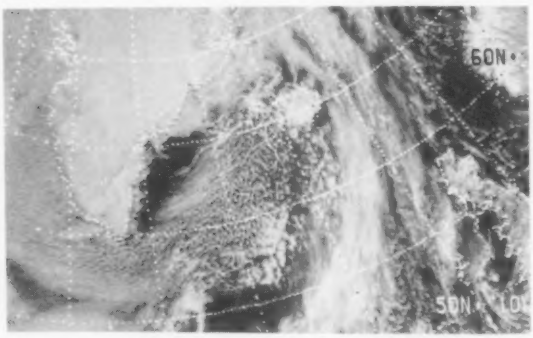


Figure 64.--The POSEIDON and MINDEN were near the center of the picture under the cumulus-type clouds.

The LOW moved over Iceland late on the 11th, and the TFBC off the northwest coast of Iceland found 52-kn winds. Most windspeeds were in the 40-kn category. Near 53°N, 22°W, a ship was buffeted by 25-ft seas and swells. The cyclone moved inland over Scandinavia on the 14th.

The Azores High had drifted southward to latitude 45°N, but it was still north of its normal position. Another HIGH moved off the U.S. East Coast. Late on the 11th a closed cyclonic circulation formed between the two anticyclones. The SOLON TURMAN had 40-kn southerly winds east of the front near 40°N, 39°W. At 1200 on the 12th, the LOW was 1009 mb at 39°N, 48°W. At 1800 two ships about 120 mi west of the LOW had 45-kn gales. North of the center the MANCHESTER COURAGE was sailing with 66-kn northeasterly winds.

The LOW was moving northward and on the 14th was 990 mb near 48°N, 45°W. The SANKOGRAIN (41°N, 43°W) had 55-kn westerly winds on her starboard bow. The highest seas around the storm were 23 ft. On the 0000 chart of the 15th, the LOW was turning northwestward as another LOW moved eastward off Nova Scotia. The 1200 chart showed the two combined.

This storm formed in the wake of a LOW that originated far enough south (26°N) to have been a tropical storm. Instead, it traveled northeastward; on the 18th as it sailed east of Newfoundland, it left a large area of flat gradient between 30° and 40°N. At 1200 a weak 1009-mb circulation developed in that area. It drifted eastward until the 20th when it started to intensify and move toward the northeast. At 0000 a ship reported 40 kn near the 1004-mb center at 40°N, 43°W. At 1200 Flores Island in the Azores group was raked by 50-kn winds. A ship north of the island had 20-ft waves. By 0000 on the 22d, the LOW had raced to 55°N, 20°W, but the pressure was still only 998 mb. At 0600 the NAESS TEXAS was hit by 63-kn winds from the south-southwest near the front (fig. 65). The storm turned eastward as it crossed the Orkney Islands and invaded Scandinavia.

Figure 65.--At 1116 the LOW was near 57°N, 11°W, and headed for the Orkney Islands.

There was strong, zonal upper-air flow over Newfoundland on the 22d when this cyclone developed. It raced eastward and turned to the northeast at 1200 on the 23d. At 0000 on the 24th, it was 990 mb about 100

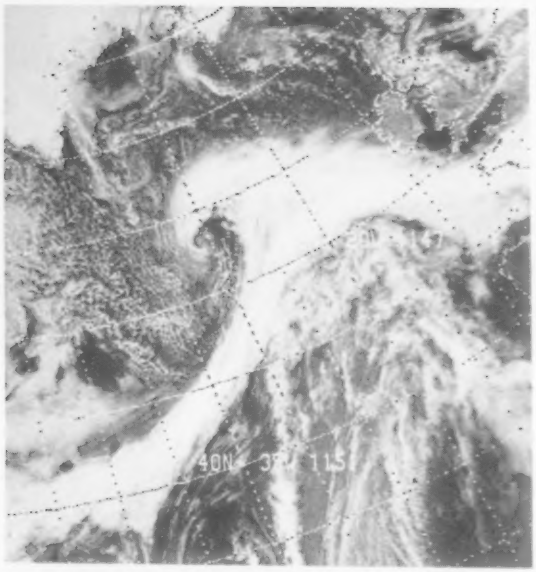


Figure 66.--The circulation center easily identified at 1147 just east of OWS Charlie.

mi south of OWS Charlie. The KAPITAN NOCHRIN at 47.5°N, 48°W, reported 52-kn northwesterly winds (fig. 66). Twenty-four hours later, the pressure had plunged to 968 mb almost directly over OWS Lima. At 1200 Lima measured 55-kn westerly winds and 23-ft seas. Other ships both north and south of the LOW were reporting 40- to 50-kn winds. At 1800 a ship north of the center had 52-kn winds and 25-ft seas, while one south of the center had 40 kn and 26 ft. Lima reported 23-ft seas at 0000 on the 26th. Icelandic fishing boats off the east coast were suffering 40- to 50-kn gales as the storm stalled for a day before it turned southward and dissipated.

Casualties--The 32,269-ton American STONEWALL JACKSON was struck by barges during a storm early in the month. The Liberian tanker UNIVERSE DEFIANCE sustained a fire and explosion off the coast of Portuguese Guinea on the 16th. High winds and heavy seas were hampering tugs towing the ship to Dakar.

The BRAVO oil rig in the North Sea about 150 mi northeast of Scotland suffered a blowout on the 22d (fig. 67). The 112-man crew was evacuated as oil sprayed 180 ft into the air. Rough seas up to 20 ft hampered efforts to seal off the well. The British motor vessel CUNARD PRINCESS arrived in New York on the 30th with heavy weather damage.

Figure 67.--A firefighting vessel sprays water on the oil drilling platform BRAVO. Note that there are fewer white caps on the oil slick near the top left half of the picture. Wide World Photo.

ROUGH LOG, MAY 1977--May was an inactive month over the North Atlantic Ocean and the eastern United States. Cyclones developing over the Great Plains were farther west and tracked more northerly than normal. They also tended to dissipate before reaching the water. The primary paths of the relatively few storms were from Nova Scotia toward the Denmark Strait and from east of Cape Cod toward Scotland. There was one long-lived storm which originated south of James Bay and traveled to the east coast of France.

According to the climatological normal, the monthly mean sea-level pressure gradient for May is the least of any of the 12 months--10 mb. This month the mean gradient was tighter with a 17-mb difference between the low- and high-pressure centers. The primary Low was 1008 mb north of Notre Dame Bay. The Azores High was 1025 mb near 35°N, 27°W, about 300 mi northeast of its normal location.

There were two anomalous Lows along the eastern slopes of the Rocky Mountains reflecting the storm pattern in that area. A negative 8-mb anomaly center dominated western Canada. Another anomaly center of minus 6 mb was over Newfoundland. The pressure over the northeastern ocean was higher than normal again this month, with a positive 7-mb center between Iceland and Scotland.

There were marked differences from climatology in the upper-air flow. The upper-air Low, which is usually near Devon Island (75°N, 80°W), dropped to east of Hamilton Inlet (55°N, 50°W). In conjunction with a ridge over central North America, this produced a deep trough off the east coast of the United States with more pronounced ridging over Iceland and Greenland. Southeast and below this ridge there was an anomalous Low over England.

Extratropical Cyclones--A frontal wave formed on a cold front near the tip of the Gaspe Peninsula on the 3d. It quickly formed a large circulation and absorbed another frontal wave moving northward along longitude 45°W. At 1200 on the 4th, it was 994 mb south of Belle Isle. The ROBERT E. LEE was 700 mi south of the center with 40-kn winds as she approached the front. Other ships in the vicinity of 50°N also experienced winds of 40 kn. On the 5th, the ATLANTICA MILANO found the 40-kn isotack southeast of Sable Island.

At 0600 on the 6th, the KARAKOUMY was very near the center of the LOW with 60-kn winds (fig. 68). At 0600 on the 7th, the SUGAR CRYSTAL near 48°N, 33°W, reported an astonishing 80 kn from the south in the southeast quadrant of the storm. On the 8th the 992-mb LOW was drifting northward; it was absorbed by another LOW approaching from the southwest on the 9th.

This was the LOW that tracked from near James Bay to eastern France. On the 7th high pressure moved south out of central Canada, and this low-pressure center was analyzed on the 0000 chart of the 8th west of James Bay. By 1200 on the 9th, it was centered just south of Long Island at 996 mb. At 1800 the ARECIBO was steaming toward New York with 40-kn northwesterly winds. The ALERT was north of the center early on the 10th with 45-kn winds from the northeast, and a SHIP in the Gulf of St. Lawrence

Figure 68.--At midday the storm was centered near 45°N, 44°W.

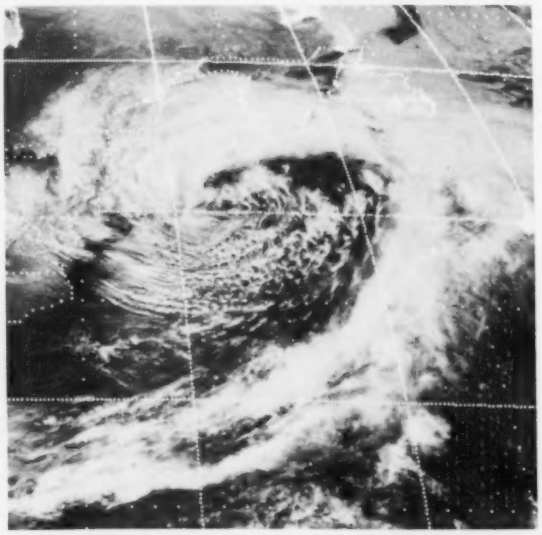


Figure 69.--The storm is centered south of Cape Sable at 1700. Heavy clouds cover New England, where they received late snow. The cloud streets off the coast indicate turbulent conditions.

fought 50-kn winds from the north (fig. 69). Boston had .5 in of snow--the latest snow has fallen there since records began in 1870. There was heavy snow in some parts of Massachusetts and Connecticut--15 in at Becket; Ashfield, 12 in; Ashburnham, 10 in; Norfolk, 13 in; and Colebrook, 10 in.

The storm was moving northeastward toward Newfoundland when the CG10 found winds of 50 kn on the 11th in the Bay of Fundy. The MARIA U., south of the center at 35°N, 66°W, was headed into 50-kn winds, 20-ft seas, and 23-ft swells. Only gale-force winds were reported until the 13th when the storm was near 56°N, 38°W, at 1200. The CEDYNIA found 56-kn winds from the west at that time near 45°N, 47°W. The storm crossed the west coast into southern France and dissipated on the 17th.

This LOW over New Brunswick on the 13th was left behind from the circulation of the LOW above. It expanded quickly as the first LOW moved eastward. The USCGC TAMAROA (40°N, 68°W) was tossed about by 76-kn westerly winds. On the 14th two ships coded as CARD and RICH both reported 50-kn winds from the north just south of Sept-Isles. At 1200 the LOW was 986 mb near Sidney, Nova Scotia.

The storm was drifting northeastward very slowly and weakening, but late on the 15th its forward motion picked up. As it approached the Denmark Strait on the 17th, it again intensified; at 1200 it was 984 mb near 62°N, 37°W. The winds were only in the 20-kn range. The LOW moved up the eastern coast of Greenland into the Arctic Ocean.

As the previous LOW moved into the Denmark Strait, a LOW moved southeastward out of northern Canada into the Labrador Sea. Another weak LOW formed near Belle Isle, and the two combined slightly east of Belle Isle at 0000 on the 18th. At 1200 a SHIP north of Sable Island radioed 45-kn northerly winds (fig. 70). On the 19th at 1200, the storm was near 56°N, 40°W, at 992 mb and turning northward. OWS Charlie was riding 13-ft seas on the 20th, and the ARNI FRIDRIKSSON (62°N, 33°W) reported 44-kn southwesterly winds through 1800. No seas were reported. On the 21st the storm was over the Greenland Sea.

A LOW moved across Canada and was over Labrador on the 25th. As the occlusion moved over the Gulf of St. Lawrence, a closed circulation developed; and at 0000 on the 26th, it was the primary LOW. At 1200 the central pressure was 992 mb near St. Pierre Island. The GREEN HARBOUR was south of the center near 39°N, 55°W, with 56-kn west-southwesterly winds. The KUNUNGUAK was south of Kap Farvel with 58-kn easterly winds and 23-ft seas on the 27th. Two Canadian vessels reported 40-kn winds over the Gulf of St. Lawrence. The GREEN HARBOUR sailing eastward at 1200 (fig. 71) was hit by what was coded as 88-kn southerly winds near the front at 44°N, 46°W. The KOHFUKUSAN MARU found 45-kn westerly winds 7° longitude to the west which continued for the next 12 hr. The MARINE ATLANTICA (46.7°N, 59.7°W) had heavy snow showers with 67-kn northwesterly winds at 1800. The EXPLORER was sailing with 20-ft swells near 39°N, 56°W, at 0000 on the 28th. At 1200 the 984-mb LOW was near 51°N, 53°W. East of the center a ship had 40-kn winds and 20-ft swells. At 0000 on the 29th, another ship had 23-ft swells near 42°N, 53°W. Later in the day a frontal wave moved off the East Coast and south of the LOW, weakening the storm as it drifted northward. On the 31st it turned northeastward to dissipate south of the Denmark Strait.

Casualties--The 51,046-ton Liberian bulkcarrier ARGONAUT, Antwerp for Seven Islands, lost her steering in a northerly gale 100 mi southeast of St. John's, Newfoundland.

Figure 70.--The storm center is indicated by a star-shaped clear area near 52°N, 47°W. There is also an anomalous clear area off the north coast of Newfoundland.

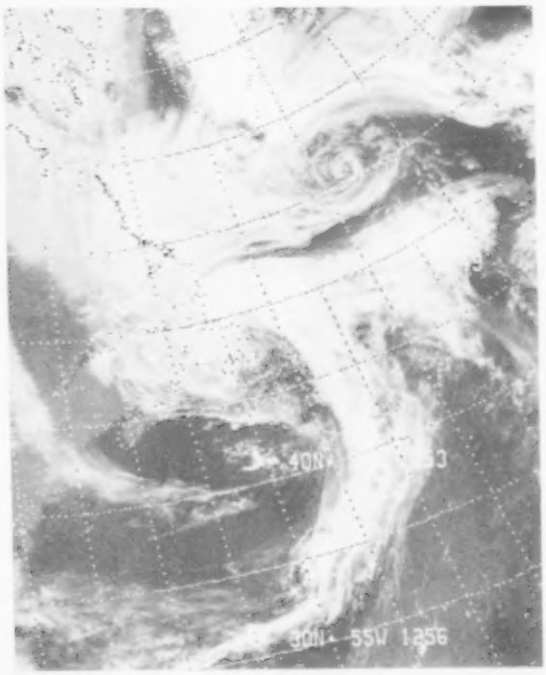


Figure 71.--At this time (1250) the LOW was over Newfoundland. The circulation southeast of Kap Farvel is associated with an older front and an upper-air LOW that is dissipating.

Rough Log, North Pacific Weather

April and May 1977

ROUGH LOG, APRIL 1977--This was a busy month for cyclone centers across the North Pacific. The storms were generally not exceptionally deep, but there were more of them than usual. The storms out of the Sea of Japan followed the usual northeasterly track to and along the Aleutian Islands. Another group that formed over and south of Honshu took an easterly path to midocean. There was an anomalous group of storms over the eastern ocean off the U.S. West Coast during the first and last weeks of the month.

The mean pressure pattern had the normal configuration--an elongated, multicentered High near 35°N and a Low near 55°N. The normal 1012-mb isobar enclosed four 1009- and 1010-mb LOW centers between latitudes 50° and 60°N between lower Alaska and the Sea of Okhotsk. The Pacific High usually has three centers from 1021 to 1023 mb along approximately 33°N. This month, however, there were only two LOWs--a 1009 mb over the Sea of Okhotsk and a 1007 mb near Kodiak Island. There were two high-pressure centers, 1027 mb near 33°N, 175°W, and 1025 mb near 32°N, 147°W.

The anomaly centers were not large and were centered near the pressure centers. A positive area ridged up into the Bering Sea from the Pacific High.

The upper-air pattern at 700 mb exhibited more of a difference from climatology than the surface. There was a closed LOW over the Sea of Okhotsk where normally there is only a shallow trough. A sharp trough extended from the Bering Strait southeastward over Bristol Bay paralleling the U.S. West Coast. This helped accentuate the ridge over the coastal mountains of North America. A large positive anomaly covered the northern United States and southern Canada.

Extratropical Cyclones--At the beginning of the month a large center of high pressure was stationary off the U.S. West Coast, forcing many cyclones on a northerly track. One of these formed on a north-south-oriented front between that HIGH and another over the central ocean at 0600 on the 2d. At 1800 the NEPTUNE TOPAZ had 45-kn easterly winds north of the center near 40°N, 155°W. By 1200 on the 3d, the 1004-mb Low was near 44°N, 153°W, and the NEPTUNE TOPAZ now had 45-kn southeasterly winds pounding her starboard. The PRESIDENT MADISON was near 37°N, 152°W, south of another small LOW, with 45-kn winds and 25-ft seas. At 1800 the BIBI fought 50-kn gales.

At 0000 on the 4th, the PACGLORY reported 26-ft seas and swells. By 1200 the pressure of the LOW had plunged to 977 mb over the Gulf of Alaska (fig. 72). Gales of 40 to 45 kn were blowing in the southeast quadrant. As the LOW moved across the Alaska Peninsula, it curved southward and again crossed into the Gulf where it died on the 6th.

Late on the 2d a LOW formed near the occlusion of a front near midocean at 44°N, 173°E. This cyclone moved east-southeastward, an odd direction for this

Figure 72.--The LOW is located over the Alaska Peninsula. Note the ridges in the cold clouds over Alaska. Another LOW north of Hawaii brought strong winds to a ship in that area.

area of the ocean. The HOYO MARU was north of the 1013-mb center with 26-ft easterly swells. A ship some distance west of the center reported 41-ft seas and swells. As the storm moved eastward on the 3d and 4th, the HIGH off the U.S. West Coast was moving northward and weakening. The PRESIDENT MADISON was at 36°N, 163°W, at 0000 on the 5th, west of the 1003-mb center. She was blown by 55-kn winds and 30-ft seas from the north-northwest.

Late on the 6th, the LOW turned north-northeastward. The ORIENTAL EDUCATOR was 350 mi southwest of the center with 46-kn southwesterly winds and 18-ft waves. As the storm approached Vancouver Island, the gradient tightened (fig. 73), and on the 8th a ship near 53°N, 143°W, reported 74-kn winds. Later in the day the track turned eastward, and the storm crossed inland.

Late on the 6th there was an area of weak low pressure with two weak LOWs south of Kamchatka. On the

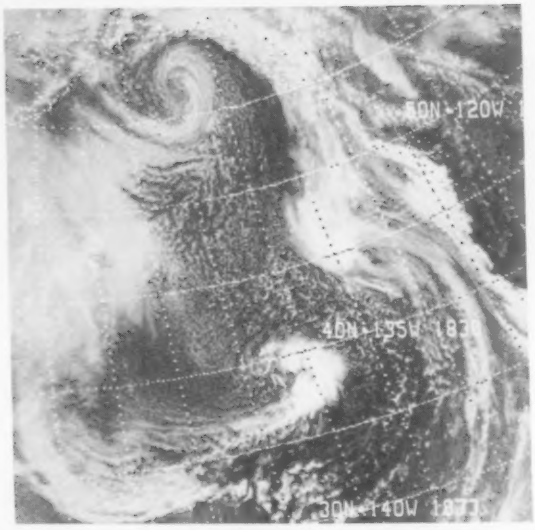


Figure 73.--The storm stretches north-south along the coast. Note the fog and low stratus along the coast.

7th, another LOW formed south of the first two and by 1200 had taken over the circulation at 990 mb near 46°N, 169°E. The WAKAURA MARU, 250 mi south of the LOW, reported 45-kn gales. The VAN ENTERPRISE was near 52°N, 168°W, with 70-kn winds on the 8th. At 1200 another ship fought 60-kn winds north of the Aleutians. On the 9th the highest wind reported was 50 kn south of the center. On the 10th the storm moved ashore over Cook Inlet.

A frontal wave developed over the East China Sea on the 8th. It moved eastward with very little change until the 12th over midocean. At 0600 the PACIFIC BEAR was near 40°N, 174°W, with 50-kn southeasterly winds. At 1200 she had 20-ft seas. Early on the 13th a trough was moving through the southwest quadrant (fig. 74). A ship reported 28-ft swells just behind the

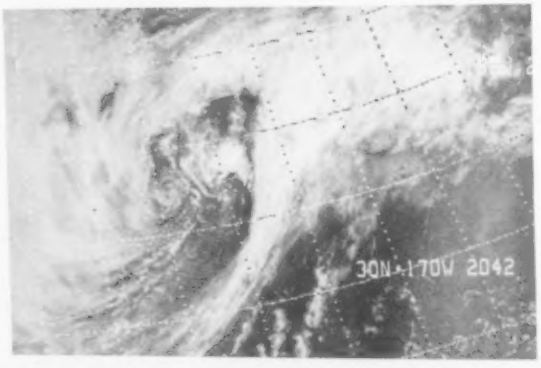


Figure 74.--The trough line is oriented northeast-southwest through 35°N, 175°E. A circulation is indicated by the clouds just to the north.

trough line. On the 14th the LOW moved into the Gulf of Alaska at 982 mb with only minimal gales. On the 15th the VAN WARRIOR was about 150 mi south of the 974-mb center with 45-kn southwesterly winds. At 0600 the ZENKOREN MARU found 33-ft swells in the same general area. The SEIAN MARU (50°N, 140°W) had 40-kn winds and 26-ft swells at 1800. The MONTIRON and NEWARK were both about 200 mi south of the LOW with 40- and 50-kn winds and 31- and 26-ft swells, respectively. On the 17th the LOW crossed into southeastern Alaska and dissipated.

This storm came from western China and was very weak until it found the fertile coastal region and the Sea of Japan. When it moved across the Tartar Strait late on the 18th, it was a large 982-mb storm. At 1800 on the 17th, the PELAMIDA was north of Hokkaido with 60-kn winds (fig. 75). The LOW moved slowly eastward across the Sea of Okhotsk. A ship southeast of Ostrov Simushir contended with 48-kn southeasterlies.

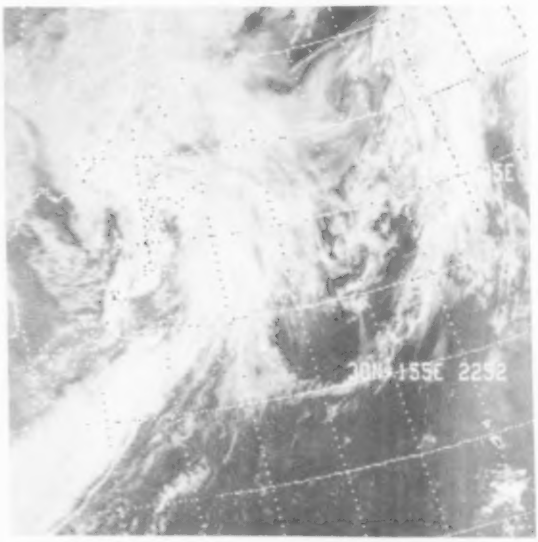


Figure 75.--At this time on the 17th the storm is just a large cloud mass. The cyclonic circulation south of Kamchatka is a frontal wave.

As the storm crossed the Sea of Okhotsk, its pressure reached 968 mb, and a USSR ship in the Kurile Basin found 50-kn winds. The ALLISON CONWAY (51°N, 166°E) had 23-ft swells. On the 24th the storm crossed into the frozen Chukchi Sea.

This storm tracked out of Mongolia and crossed the Tartar Strait late on the 22d. Like the previous storm, it grew rapidly as its circulation reached the Sea of Japan. It treated Russian fishing vessels on the Sea of Okhotsk to 45-kn gales and near freezing temperatures on the 23d and 24th. The VAN WARRIOR was caught by 50-kn northwesterly winds 400 mi southwest of the 980-mb LOW at 47°N, 155°E, at 0600 on the 24th.

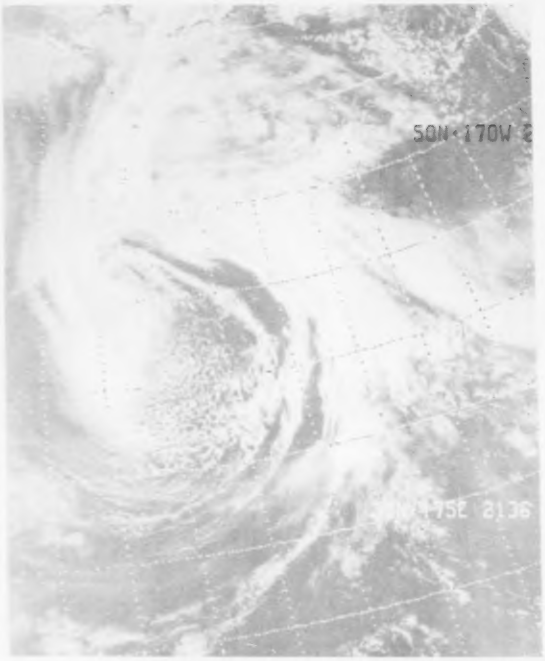


Figure 76.--This storm has moved farther out over the sea late on the 24th and is better organized than the previous storm.

At 0000 on the 25th, the VAN WARRIOR, moving southwestward away from the storm, ran into higher 60-kn winds (fig. 76). Other ships in the area were not finding the winds as strong, but 25- to 33-ft waves were measured. At 1200 the SEIAN MARU (43.4°N, 161.8°E) had 40-kn westerly winds, 16-ft seas, and 33-ft swells.

On the 26th the storm started to weaken and broke up into multiple centers. The original LOW decayed late that day, and the LOW to the southwest became the primary storm. The winds south of this center were blowing at nearly 40 kn, with swells running around 16 ft.

Casualties--There are no known weather-related casualties at this time.

ROUGH LOG, MAY 1977--The storm paths across the North Pacific were widely diversified. The storms normally track northeastward off the east coast of Japan to the Aleutian Islands and into the Gulf of Alaska. This month the major connection with climatology was a general northeasterly direction. There was no favorite area of cyclogenesis as storms formed all across midocean. The Gulf of Alaska was still the favorite destination. Several storms had definite southerly components to their tracks, and more than usual were stationary at some point during their existence.

The mean sea-level pressure over the North Pacific closely matched climatology. The pressure centers were slightly more intense, with the Aleutian Low 2 mb lower at 1007 mb and the Pacific High 3 mb higher at 1026 mb. The Aleutian Low was over the Bering Sea at 60°N, 170°W. The Pacific High was near 32°N, 145°W. There were anomalous low centers along the eastern slopes of the Rocky Mountains.

The significant anomaly centers were a negative 5 mb over the Bering Strait and a negative 8 mb over central Canada. There was also a large flat area of positive 2- to 3-mb departure that stretched from the center of the Pacific High to the Sea of Okhotsk.

The upper-air pattern was mainly zonal with major troughs along both coasts.

Extratropical Cyclones--The first half of the month was fairly quiet with only a few cyclones of any significance. This was one of them. On the 2d a multicentered storm moved across Japan. By the 3d at 1200, it had consolidated into a 978-mb center near 43°N, 165°E. The VOLNA was about 250 mi southwest of the center with 45-kn westerly winds and 23-ft seas. At 0000 on the 4th, the MEDELENA (37°N, 173°E) had 50-kn southerly winds on her starboard side as the front approached. North of the front and 300 mi south of the center, the TACOMA MARU was sailing into 50-kn winds and 20-ft swells.

By 1200 on the 4th, the 964-mb LOW had crossed into the Bering Sea (fig. 77). The DAIKEI MARU at

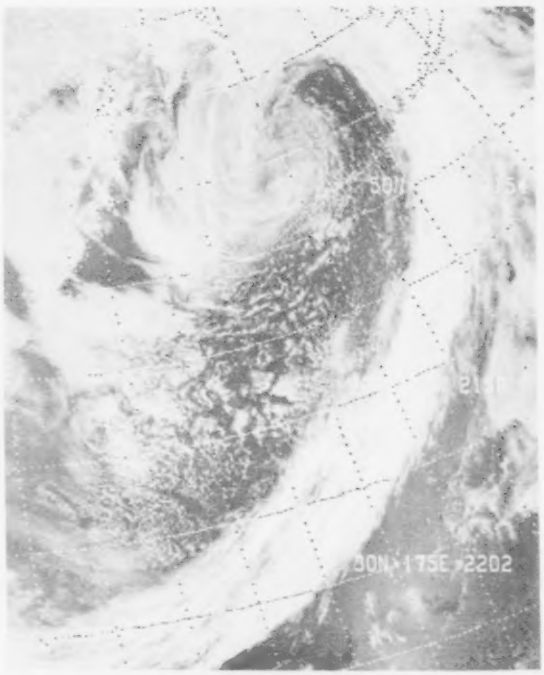


Figure 77.--The storm is centered near 56°N, 177°E, late on the 4th. The front stretches from Alaska to Japan.

49°N, 177°E, was headed eastward with 40-kn winds and 33-ft swells on her stern. Far to the west a ship near Mys Lopatka had below freezing northwesterly 50-kn winds. Other ships in the southern quadrant reported 40-kn gales. Twelve hours later the DAIKEI MARU was still riding 20-ft swells. The INDIAN MAIL was not far away at 50°N, 176°W, with 30-ft swells. At 1200 on the 5th, they were 33 ft, and the winds were 45 kn.

On the 6th the LOW started to weaken as it approached the Bering Strait. It became stationary and dissipated on the 8th.

During the second week of the month the ocean was dominated by high pressure. On approximately the 13th, cyclones started making inroads into the high pressure as the centers weakened and drifted southeastward.

Late on the 12th, a frontal wave developed near 27°N, 142°E. It moved eastward rapidly under the zonal flow. On the 14th the KOREAN PEARL was northwest of the center with 52-kn winds as the LOW pressed against an elongated HIGH to the north. The surface LOW came to an abrupt halt on its easterly track late on the 14th when it came under direct influence of an upper-air LOW that formed east of Japan on the 12th. By the 15th the LOWs were vertically stacked and stationary. At 1800 on the 14th (fig. 78), two ships along 35°N and north of the center reported 43- and 48-kn winds from the east. At 0000 on the 15th, the 992-mb Low was near 32°N, 162°E. The ERISORT near 35°N, 157°E, about 300 mi northwest of the center boasted of 50-kn winds. At 0600 they were 60 kn.

The continuing circulation built the swell waves, and at 0000 on the 16th, the HAGOROMO MARU was east of the center and just north of the front with 30-ft swells and 45-kn gales. At this time another LOW was moving northeastward from Japan's southern coast. By the 17th the new cyclone had absorbed the older one.

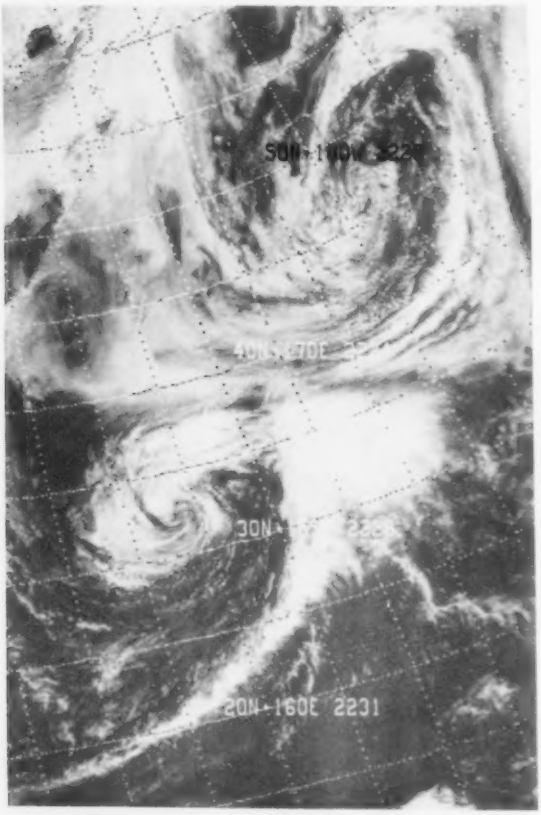


Figure 78.--The satellite image indicates the storm is centered near 33°N, 159°E, at 2228 on the 14th. Another cyclone is near 47°N, 178°W, and there are high thin clouds over the HIGH north of the storm.

Figure 79.--Late on the 16th the storm is over the Japan Trench and Kuroshio Current off eastern Honshu.

This was the cyclone that absorbed the one previously described. It had its origin south of Shikoku on the 15th at a frontal occlusion. The center passed south of Tokyo late on the 15th and early on the 16th, and a ship found 26-ft swell waves just off the coast (fig. 79). At 1200 the PESTOVO was near 40°N, 147°E, with 60-kn easterly winds. This Low was centered at 40°N, 147°E, at 988 mb on the 17th at 1200. The CHIKURA MARU (43°N, 154°E) was fighting 40-kn easterly winds and 33-ft southeasterly swells.

A long, narrow high-pressure ridge was blocking both the northerly and easterly movement of the storm as it pushed toward the north along the Kurile Islands. Maximum winds were in the 40-kn range on the 18th. On the 19th the high-pressure ridge defeated the LOW.

Two weak LOWs over the Gulf of Alaska on the 25th joined forces on the 26th to produce a 995-mb LOW near 52°N, 135°W. The WEST OCEAN was near 48°N, 136°W, with 40-kn winds at 0600 and 45-kn at 1200. The seas were running at 16 ft, but by 1800 they were 20 ft (fig. 80). At 0000 on the 27th, the GALVESTON (50.6°N, 130.8°W) had 45-kn southeasterly winds and 16-ft seas. The YEH YUNG was 180 mi to the south with 26-ft seas and 36-ft swells. On the 28th the LOW evaporated near the Strait of Juan de Fuca.

Casualties -- The AUSTRAL ENSIGN (21,150 tons) arrived at Auckland with heavy weather damage. The 18,250-ton LIBERIAN STATESMAN encountered heavy weather 3 days out of Portland, Ore., enroute to Pusan, during the last week of the month. The vessel put into Seattle for repairs.

Figure 80.--The center of the LOW is near 50°N, 134°W, at this time on the 26th. It broke up on the 28th over the mountainous West Coast terrain.

Marine Weather Diary

NORTH ATLANTIC, AUGUST

WEATHER. The favorable weather that is characteristic of summer continues into August, the warmest month of the year over the North Atlantic. The monthly pressure analysis shows the 1022-mb subtropical High centered near 35°N, 43°W, while the Icelandic Low, a broad, flat, east-west trough, reaches its lowest pressure (1008 mb) over Hudson Strait.

WINDS. Over the middle latitudes (40° to 60°N), winds from the southwest through the northwest occur with the greatest frequency. North of latitude 60°N, they become northerly between Greenland and Iceland, and variable south of Iceland and over the southern Norwegian Sea. The prevailing winds over the North Sea are from the westerly quarter of the compass. Between 40° and 25°N, the prevailing direction is from the north and northeast over the extreme eastern Atlantic, and from the south and southwest over the western ocean. Northwesterlies--known by many names, including mistral, etasians, and maestro--blow over the Mediterranean Sea. The northeast trades of the Atlantic lie principally between 25° and 15°N, extending to the South American coast over the Caribbean Sea. Near the approaches to the United States at these latitudes, the trades become more easterly- the Gulf of Mexico has prevailing easterly winds. Southeasterlies are dominant near the Equator, between South America and Africa. Windspeeds on the North Atlantic in August average slightly more than force 3, with lower speeds over the western Mediterranean, the Davis Strait, and the Gulf of Mexico.

GALES. Winds of gale force, except in tropical cyclones, are very infrequent south of 52°N. North of this latitude, gale frequencies of about 5 percent are fairly common, with maximum frequencies of 10 percent or more over the Norwegian Sea and the waters south and west of southern Greenland.

EXTRATROPICAL CYCLONES. A few moderately strong summer LOWs move about north of 40°N. Storms that attain severe intensities during August are usually of tropical origin. Primary storm tracks for extratropical cyclones are from Hudson Bay to Davis Strait, and from east of the James Bay region and the eastern Grand Banks to just south of Iceland and then eastward through southern Scandinavia. A short primary track lies off the U. S. East Coast. A secondary storm track crosses eastern Lake Superior before joining the primary track over central Quebec.

TROPICAL CYCLONES. August is one of the principal months in the North Atlantic hurricane season, ranking second behind September in tropical storm development and also in the number of these storms that attain hurricane force. An average of 2.4 tropical storms occur during August, and 1.5 or 2 out of 3 develop to hurricane intensity. A maximum of seven cyclones occurred in August 1933; and, in contrast, no storms were reported during 1941 and 1961. In general, the level of tropical cyclone activity increases as August advances, with the likelihood of storm occurrence being more than twice as great in the last 10 days as during the first 10 days of the month. The spawning area of tropical cyclones is much larger in August than during the preceding month. Some tropical cyclones originate as disturbances over southwestern portions of the "African Bulge," intensify into tropical depressions southwest of the Cape Verde Islands, gather strength as they are carried across the lower latitudes of the North Atlantic by the prevailing easterlies, and then enter the Caribbean, Gulf of Mexico, Florida, or the western Atlantic, as fully developed hurricanes. A characteristic of this activity is the split mean storm track around the Bahamas, with one branch passing to the north of the islands, where it recurves off Cape Hatteras, and the other over the southern portion of the island chain.

SEA HEIGHTS of 12 ft or more are encountered more than 10 percent of the time over a portion of the northern ocean south of southern Greenland and several hundred miles southwest of Iceland. Two other areas are also observed. One lies west of the British Isles, while the other is hosted by the Denmark Strait.

VISIBILITY. In general, fog is both less frequent and less extensive than earlier in the summer. Percentage frequencies of visibilities less than 2 mi occur 10 percent or more of the time north of a line from Cabot Strait southeastward to include the Grand Banks, thence northeastward to near 50°N, 35°W, northward to 65°N, 35°W, then southeastward to Scotland. The line then extends north- and eastward to the northern coast of Norway. A 20-percent oval-shaped area, about 600 mi in diameter, is centered off Newfoundland near 50°N, 50°W. Another 20-percent area is north of Iceland over the southern Greenland Sea.

NORTH PACIFIC, AUGUST

WEATHER. Mild summer weather continues over the North Pacific. Fog decreases, but both tropical and extratropical cyclones are more numerous. Temperatures reach their maximum for the year. By the middle of the month, the 1010-mb Aleutian Low has reappeared over the northern Bering Sea, near 61°N, 178°W. The subtropical High (1025 mb) is centered near 38°N, 152°W, in August.

WINDS. The northeast trade winds are the most persistent feature. They prevail south of about 35°N, and to 40°N over the eastern ocean. Over the Philippine and South China Seas, they quickly shift to the southwest monsoon. Off the Asian coast, the winds turn to southerly, and continue to shift to southwesterly over the northern latitudes. Over the western Bering Sea, they are westerly. Over the central ocean north of latitude 40°N, and over the eastern Bering Sea, the prevailing direction is southwesterly. The winds over the Gulf of Alaska are westerly, shifting to northerly along the American coast. Winds of force 3 to 4 generally account for over 50 percent of the speeds.

GALES, although unusual in areas not affected by tropical cyclones, do occur more than 5 percent of the time over the heart of the Bering Sea, along the easternmost capes of Kamchatka, and northwest of the Bering Strait. Owing to the influence of tropical cyclones, another small area of greater-than-5-percent frequency is centered near 25°N, 134°E.

EXTRATROPICAL CYCLONES. The number of extratropical cyclones is slightly higher in August than in the preceding month. Most of these storms form off the coast of Japan and move northeastward into the Bering Sea. Others enter the Bering Sea after developing off the southeastern tip of Kamchatka; these storms often journey as far north as Kotzebue Sound. Still another primary cyclone track scampers toward the Gulf of Alaska from a point near 51°N, 158°W.

TROPICAL CYCLONES. The frequency of tropical cyclones in the western North Pacific reaches a peak in August and September. About five tropical storms can be expected in August; three or four reach typhoon intensity. Typhoons in August are displaced farther to the north than in July and have less of a tendency to pass directly over the northern Philippines. Some move directly toward Japan and Taiwan; others may pass over Japan after recurving over the Yellow Sea. Those storms that do enter the South China Sea usually move west-northwestward into the Gulf of Tonkin and North Vietnam.

Over tropical waters west of Mexico, four or five tropical storms usually occur--a maximum for any month. The average duration of these storms is 6 days, and about half attain hurricane intensity. As in July, cyclones usually move in a west-northwesterly direction out to sea, where they almost always die after meeting colder waters and more stable air. Occasionally, however, one recurves before it has moved too far from the coast and moves inland over Baja California or the Mexican mainland.

SEA HEIGHTS. During August, sea heights of 12 ft or more are rare and occur less than 10 percent of the time across the entire North Pacific Ocean.

VISIBILITY improves very slightly during August. An area about 300 mi in diameter, where the visibility is less than 2 mi over 40 percent of the time, is centered just south of the Kamchatka Peninsula. The 30-percent line surrounds this area, reaching into the Sea of Okhotsk and to the Near Islands. The 10-percent line includes the southeastern half of the Sea of Okhotsk to 40°N at 160°E, along 40°N to 170°W, to 53°N, 137°W, to the Kenai Peninsula of Alaska. This area includes all of the Bering Sea.

NORTH ATLANTIC, SEPTEMBER

WEATHER. With the approach of autumn, subdued weather conditions that characterize the summer season over the higher latitudes gradually give way to increased cyclonic activity resulting from moderate intrusions of colder air. The Icelandic Low deepens to about 1006 mb, and is centered roughly halfway between Iceland and southern Greenland. The Azores High (1021 mb), centered near 33°N, 40°W, is a little weaker than in August.

WINDS. Almost without exception, the prevailing winds are westerly between 40° and 60°N. However, over the Grand Banks and the waters east of there to about 40°W, southerly winds prevail, and winds are variable south of Nova Scotia and over the Bay of Biscay. Speeds across this latitudinal belt are generally about force 4. South of 40°N, somewhat lighter winds average about force 3. Wind directions are frequently variable between 30° and 40°N, along the axis of the subtropical High, but northerlies dominate between 20°W and the Strait of Gibraltar. Between 30° and 10°N, easterly winds predominate over the western ocean (northeasterly over the Caribbean Sea), and northeasterly winds are the rule over eastern waters. Northwesterly winds blow over the Mediterranean, and southeasterlies are common over the extreme southern North Atlantic. Northerly winds prevail south of the Denmark Strait, while southwesterlies predominate over the Norwegian Sea. Northwesterly and southeasterly winds are most common over the southern approaches to the Davis Strait. Windspeeds north of 60°N average force 4 east of Greenland, but near the Davis Strait, more reports of force-2 winds are received than of any other speed group.

GALES. The frequency of gales increases in September, particularly over northern latitudes. Frequencies of 10 percent are found just south of Greenland's southern tip, over the open waters between northern Labrador-southern Baffin Island and southwestern Greenland, over the Norwegian Sea, and over the waters north and south of Iceland. The highest frequency, 20 percent, is found over waters well north of Iceland, and over a portion of the Norwegian Sea. Elsewhere, 5-percent frequencies are fairly common north of 50°N. South of 40°N, gales are unlikely to be encountered except in storms of tropical origin.

EXTRATROPICAL CYCLONES are more frequent than in August, and occasional severe storms may be encountered. Primary storm tracks lead northeastward from the waters off Labrador and Newfoundland to southern Iceland, and then over the Norwegian Sea. Another major storm track enters the Davis Strait from the Hudson Bay-northern Quebec region, while a third advances up the Baltic Sea from southern Scandinavia into Russia. One secondary storm track crosses the Straits of Mackinac on its way from the Great Plains to the primary track over Labrador. The storm track off the U.S. East Coast has moved seaward and extends from off Cape Hatteras to Sable Island.

TROPICAL CYCLONES. Tropical storm activity reaches a peak in September. Climatology indicates that an average of 3.3 tropical storms occur in September, 2 of which develop to hurricane strength. As many as seven tropical storms were reported in September (1949), while in 1930 there were none. The entire western ocean is subject to these storms, many of which originate east of the West Indies and move westward over or north of these islands, either to enter the Gulf of Mexico, or to recurve northeastward over western waters. Some storms entering the Gulf recurve over Florida and often parallel the U.S. East Coast. Another breeding ground for tropical cyclones is over the Caribbean, east of Nicaragua. Many trop-

ical storms or hurricanes are still packing considerable punch when they reach northern shipping routes.

SEA HEIGHTS of 12 ft or more have a frequency of 10 percent or higher over most of the North Atlantic between 50° and 65°N, while small areas of 20-percent frequency occur off Greenland's southern tip and over the Denmark Strait.

VISIBILITY. Percentage frequencies of visibility less than 2 mi exceed 10 percent north of a line drawn from the western Labrador Sea eastward to 57°N, 48°W, and then southwestward to encompass all of Newfoundland and the Grand Banks. From there, the line extends north-northeastward to the waters south of the Denmark Strait, and then eastward, barely missing the southern tip of Iceland, before dipping southeastward to include the Pentland Firth and the Hebrides. The line then passes east of the Shetland Islands before entering the Norwegian Sea midway between Iceland and Norway. Percentage frequencies of visibility less than 2 mi decrease to less than 10 percent over the central and northern portions of the Davis Strait, but increase to more than 20 percent over the northern reaches of the Labrador Sea above 60°N, and over the waters north of Iceland, east of the Denmark Strait. Over a small portion of the latter area, near 69°N, 16°W, the percentage frequency of visibility less than 2 mi exceeds 30 percent.

NORTH PACIFIC, SEPTEMBER

WEATHER over the North Pacific continues to be generally pleasant in early September, but, as the month advances, early winter-type storms occur over the northern shipping lanes. Western portions of these routes are also subject to tropical cyclones. A closed Aleutian Low reappears in September, centered over southwest Alaska, with a central pressure of 1007 mb. The 1021-mb subtropical High, near 36°N, 146°W, has weakened considerably and is centered about 300 mi southeast of its August location.

WINDS. The prevailing winds over the middle latitudes of 40° to 60°N are from the western quadrant, shifting to more southerly near the Asian coast, and northerly near the American coast. Over the Bering Sea, they are northwesterly, shifting to northerly over the Bering Strait. The northeast trade winds are predominant south of 30°N, shifting to the north along the American coast, and southwesterly winds predominate over the southern Philippine Sea and South China Sea, where the southwest monsoon is firmly established. There are two areas where the winds appear to be out of phase. One is the northern Gulf of Alaska, with prevailing easterlies; and the other is along the coast of southern China and the East China Sea, with northeasterlies. The average speed is force 3 to 4.

GALES. Winds of 34 kt or higher are encountered between 5 and 10 percent of the time over much of the open Pacific north of about 45° to 50°N over eastern waters, and between about 37° and 45°N over western waters. A typhoon-influenced area of frequencies greater than 5 percent extends from the East China Sea to the Philippine Sea.

EXTRATROPICAL CYCLONES. Well-developed extratropical storms occur more frequently in September than in August. Most of these move northeastward from the Japanese Islands to pass over southwestern Alaska. Others enter the Gulf of Alaska from the waters south of the eastern Aleutians. Storm tracks are displaced southeastward from those of August.

TROPICAL CYCLONES. On the average, four or five tropical storms can be expected in the western North Pacific in September, almost as many as in August. About three of these will achieve typhoon strength. These storms usually originate in the lower latitudes west of about 150°E, and initially move west-northwestward. Some travel across the northern Philippines and the South China Sea, while others recurve in the vicinity of the Philippine Sea to pass over or near the Japanese Islands.

About three tropical storms will whirl off the Mexican coast in any given September. One or sometimes two will usually become a hurricane. These storms either originate over the waters off southern Mexico and move northwestward parallel to the coast (and sometimes inland), or develop near the Revillagigedo Islands and move westward out over the open ocean.

SEA HEIGHTS of 12 ft or more are common 2 to 10 percent of the time north of about 35°N over eastern waters, and north of about 30°N over western waters (excluding the Bering Sea)--as well as over the South and East China Seas, the Gulf of Tehuantepec, and the lower Gulf of California. Two areas of maximum frequency greater than 10 percent are within an elliptically shaped area between 46° and 50°N, and 162° and 179°E, and over the Okhotsk Basin.

VISIBILITY. Fog is less prevalent in September than in August, but it is still frequent north of about 40°N. Frequencies of 10 percent or more of visibility less than 2 mi are common over the waters between 40°N and the Bering Strait, west of 145°W, and east of 150°E. However, the Alaska Peninsula and the Gulf of Alaska, included within the above area, host frequencies of less than 10 percent. A region of frequencies greater than 20 percent surrounds the waters of southern Kamchatka southwestward to the central Kurils, then eastward to Ostrov Beringa.

☆ U. S. GOVERNMENT PRINTING OFFICE :1977--240-854/3

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